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APRIL 1968

SCIENCE TODAY

FOR EVERYMAN

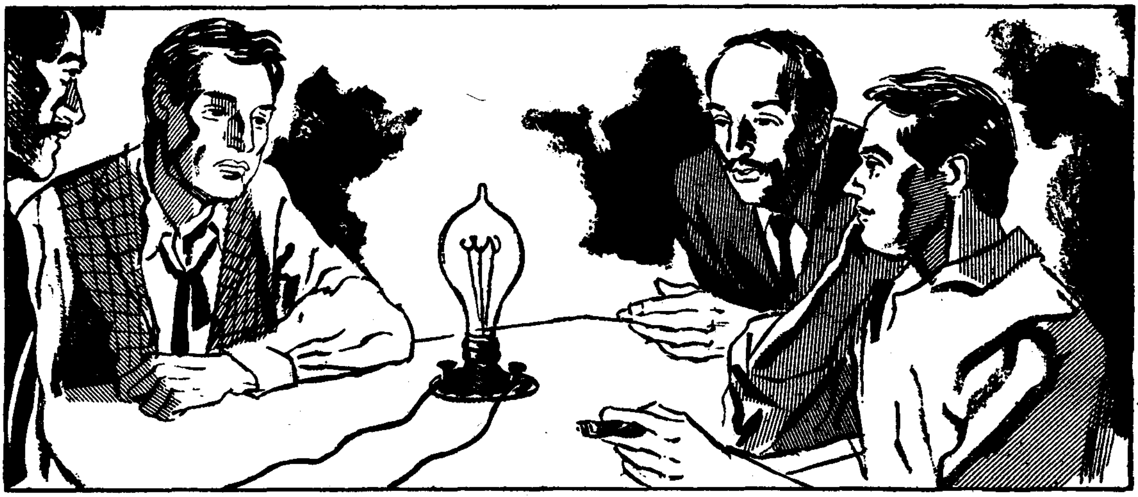
WINGS ON OUR SKIES

MARVELS OF PLANT BREEDING

PRE-HISTORIC SOUTH INDIA

MAN THE CREATOR

15 CENTS IN CEYLON



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SCIENCE TODAY

Editor
Surendr Jha

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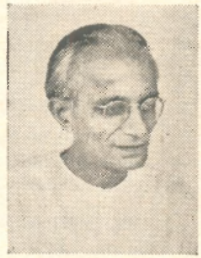
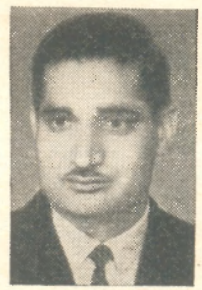
About the Authors



H. D. SANKALIA (*Beginning of Civilisation in South India*) is Professor of Proto-Indian and Ancient History at the Deccan College Post-graduate Research Institute, Poona and also Professor-in-Charge of the Department of Ancient Indian Culture and Archaeology, University of Poona.

A Ph.D. from London University, where he worked with Sir Mortimer Wheeler and Dr. Ernest Macky, Dr. Sankalia has led several archaeological expeditions in various parts of the country. He is a member of the Permanent Committee of the International Congress of Prehistoric and Protohistoric Sciences.

He has written for SCIENCE TODAY once before on cultural divisions of India (August 1967).



D. S. ATHWAL (*Marvels of Plant Breeding*) is Assistant Director of the International Rice Research Institute, Philippines.

From July 1951 till January 1955, he was a Colombo Plan Research Fellow and Research Officer on the staff of the Sydney University, Australia. The same University awarded him his Ph.D. After his return from Australia in 1955, Dr. Athwal worked for three years as Assistant Wheat Breeder in the Department of Agriculture in Punjab. In 1958 he joined the Punjab Agriculture University as Economic Botanist, later becoming Professor and Head of the Department of Plant Breeding. In July 1966, he went to the USA as a visiting professor with the Ohio State University for eight months. His appointment to the IRRI came in August 1967.

Winner of the S. S. Bhatnagar Award for 1964, Dr. Athwal's work includes the evolutions of the world's first hybrid *bajra* and high-yielding dwarf wheat varieties—the P.V. 18 and the Kalyan-227. The most outstanding work initiated by him is the evolution of the triple dwarf wheat, a highly productive line.

BRUCE FRISCH (*Man the Creator*) is a regular contributor to the US monthly *Science Digest* where he had also worked as Assistant Editor for some time. His articles have appeared several times in SCIENCE TODAY, including one on " Men Made to Order " (May 1967).

Between Us...

IT is ironical that the tenth anniversary of the passing of Scientific Policy Resolution should coincide with a statement by Dr. K. L. Rao, Union Minister for Irrigation, that 40,000 engineers and diploma holders in India are unemployed and that their number will double in three months. The Resolution had said that as the wealth and prosperity of a nation depended on how effectively it utilised its human and material resources through industrialisation, the government aimed at pursuing a policy of training and educating the country's enormous manpower to turn it into an asset.

Creating a large army of trained personnel is important not to India alone. Britain was lamenting last year that her supply of qualified scientists and technologists, especially of the latter, was inadequate to meet her overall national demand. Even in the United States it is not unusual to come across periodic exercises at comparison with Russia regarding the yearly outturn of engineers and technologists in the two countries. The number of trained technical personnel has come to be accepted as an index to a country's industrial progress.

In India, there were 713,000 scientific and technical personnel at the end of 1966, according to a report published by the Research Survey and Planning Organisation of the CSIR. This represents only 0·14 per cent of the total population. In a country where rapid economic growth is a condition for survival, the importance of a full and proper use of its limited supply of qualified scientists and engineers cannot be over emphasised. Yet, out of this figure, as many as 10·4 per cent were reported to be unemployed and 18·6 per cent held jobs which were outside the area of their scientific or technical training.

It is clear that India has not pursued any manpower utilisation policy. There have been no periodic assessments, no forming of judgements, and no decisions on the requirements for scientists and technologists and on the means by which these requirements might be met. Even while planning for education and industry, no serious attempt seems to have been made to decide what fields of research would be in the long-term interest of the country and which of them should command priority.

The pattern of research a country should follow is in most cases fixed in advance. It depends on the nature of the area, the needs of the people and the character of the scientists who are available at the start. Economic geology, water resources, natural products, climate and special characteristics of the people form some of the determining factors; though at times scientific research is also bound up with the nature of the product. Powerful economic and political factors influence the reasons for developing industries with a high content of skill and ingenuity. And projects leading to exports or substitution of imports, and those which promise high and quick returns, are preferred.

In other words, every country works out its own strategies for research and development in harmony with its economic, social and political goals. All countries, however, need increasing numbers of men and women in science, engineering, technology and management to implement their developmental programmes. To ensure this, they must raise a very large number of para-technical workforce trained, if necessary, through crash programmes (like mass participation in dam building or construction of "backyard" blast furnaces in China) to provide speedily the needed technological base. They must at the same time develop strong technological skills in highly selective, specific areas to build a capacity that can face world competition.

The chief purpose of the latter group will be to improve and accelerate the practical application of new ideas to meet the world market needs. Since this can come only from a talented group of scientists and technologists, with capacity to initiate and sustain the flow of new and improved products, it has to be a group dealing in the most sophisticated technologies. In India, it would mean creating a few, selected centres of research and development around the best of brains available in the country. They alone can break new and economically rewarding grounds.

It must be remembered that there is always a lead time, extending over years, for certain types of research and for developing necessary industrial skills. The slow and less organised societies are, therefore, bound to suffer most if they let the time go by. Ignoring the aims set in the Scientific Policy Resolution has not diminished their value. Rapid economic growth through effective utilisation of human and material resources continues to be the only way out of India's backwardness and poverty.

Letters

"A Summer Science Institute"

I read with great interest the article by Professor Hafner (Dec. '67 SCIENCE TODAY). As a person educated both in India and the United States, I wish to comment on the situation of science and math teaching in India. My first contact with this summer programme began when I was an M.Sc. student and instructor at Bombay University in 1962. I attended with great interest and enjoyed the programme on science films. The only other educational opportunity for me through films had been last year at Yale through Messenger Lecture Films of Richard P. Feynman. In 1962 at Bombay, I had the rare opportunity to hear visiting American scientists whose general knowledge in the sciences left a definite positive impact upon the teachers. An AID teachers' team left an image of hard working Americans who helped in starting a scheme with great potential for the future, in spite of the difficult working conditions in India. Often they had to carry distilled water for drinking but there was never a complaint.

These institutes were so popular that they grew from 4 to 16 and now to over 50 in successive years. Though I have not followed the accomplishments of these institutes closely except the one at Jaipur (Rajasthan University), they have helped in establishing a closer contact among high-school and college teachers than had ever existed. Every experience indicates that these institutes are beginning to create an atmosphere where a possibility of success exists.

The approach of teachers for these summer institutes should be primarily to create an atmosphere of interest in science rather than to force examinations and Feynman Lectures upon the participants. As for the Feynman Lectures, since most of the graduate students at a well-known university in the United States could not answer questions from them in their 1965 Ph.D. qualifying exams, how could one expect teachers with B.Sc.'s from remote areas in India to learn so much in such a short period of time? Many modern schools in the US have abolished exams and this has yielded very promising results. In addition, under the present education administration in India, it would adversely affect the future of the participants.

All observations lead to two important points for discussion: first, the comprehension of science in a foreign language and second, the methods of education in India. These are interrelated in a way. I personally know the tragic fact that most teachers do not keep up with material outside the syllabus and find an easy excuse by covering the syllabus material through old or outdated notes. The administration of universities and colleges avoids responsibility by administering abstract examinations to the students, only about every two years, that are mostly devoid of estimating past achievements or other knowledge of the students. The rigid definitions of the topics in a syllabus do not allow the freedom of courses for the teachers. Critical questions are often suppressed. As a result there is a huge gap among various disciplines of science in problem solving and in laboratory training.

The language problem not only affects areas of education but poses more serious challenges to India. But the underlying problem is whether or not students can think in English. There exists no sufficient scientific vocabulary in other regional languages. Hence, a standard memorisation and presentation of theories has resulted. The language problem exists everywhere in the sense that the most accurate grasp of great scientists' works can be obtained by reading them in the original. I will not go into details of practical and social acceptance of one language in India — one of the most difficult problems concerning the future progress of India. I invite scientists to come up with a feasible solution.

Ravi Dutta Sharma
Temple University,
Philadelphia

It was shocking to read Everett Hafner's article "A Summer Science Institute" in the December issue. I have also attended a summer institute (in Chemistry in 1964 at Vallabh Vidyanagar) and have met several ex-participants from different summer institutes from time to time. From nowhere did I get the kind of impression created by the above article.

In the institute I attended there was no attempt to hold tests. Though some people from other institutes I have met did have tests, there was no talk of any resentment from the participants.

It appears that there was either something wrong with the selection of participants at the particular institute Prof. Hafner attended or that the director did not succeed in creating the proper atmosphere among the participants from the beginning. The object of any test should have been to judge the success or failure of the programme, rather than the ability or worthlessness of the participants as teachers. If the participants had been given this background, they would perhaps not have felt so nervous and afraid of losing their jobs. I hope somebody will come forward to rectify the very bad impression created in America.

I must admit as a participant, however, that the UGC has not taken the matter of summer institutes very seriously and the money spent is practically wasted, at any rate at the college level. Most of the participants are junior people who cannot influence the syllabi and most of the new ideas they are exposed to at the institutes have no occasion to be used in teaching. Even the directors and lecturers involved with the institutes do not seem to think it worth while to make any changes in the syllabi of

their own institutions. The year round, we go merrily along with the same old syllabi and the same old text-books.

The participants can bring back a few books, the nature of which varies from institute to institute, even at the same level. No follow-up programmes or supplies of books, journals or teaching aids (like charts or models) are arranged, not even for the colleges where the participants teach.

I have written several letters over the years to both the UGC and the US AID Mission in New Delhi. They have always said that follow-up programmes were under consideration, but nothing seems to be coming out of the consideration.

It all seems easy come and easy go with the time and money spent at the institutes. Is it any wonder, then, if some of the participants also take it as a pleasant summer holiday, expenses paid?

I hope your timely publication of this article in India will tend to improve matters.

A. P. Bais

Head, Dept. of Chemistry,
Dayanand College, Ajmer

I read with keen interest the article "A Summer Science Institute" by Prof. Everett M. Hafner. I myself had participated in the summer institute for college teachers of physics in Waltair in June 1967. It was amusing to find that the problems were identical and still unsolved.

Though the Summer Institute at Waltair was adequately planned, I doubt whether it was really planned with the aim of familiarising teachers with new teaching techniques. It served rather as a refresher course for us, reminding us of what we had learned as M.Sc. students and then forgotten as there was neither the scope nor any time to go through them again.

Everyday there were the ritual lectures by the local teachers, delivered with mastery. For the first few days the participants listened eagerly and took down every thing spoken or written on the black-board. Later, when it was discovered that the American text-books contained all those and more, note-taking ceased; soon the attentiveness was gone too.

The American experts provided a change. Topics were discussed in conversational tones and only lighter topics like the structure of the eye, etc. were dealt with. The participants became light-hearted and, as if the memories of their old student days had returned to them, they became jovial and began to cut jokes. The whole thing became a noisy picnic party.

Some one raised a question about the capability of these people in inducing their heads of departments or administration to introduce any change in the already existing system. When this topic was discussed, it was suggested that professors and deans in charge of faculties should be invited as observers. But this would have created administrative problems like paying them allowances, etc., and there was no specific head under which these expenses could be borne.

We were shown some simple instruments like water voltameters, galvanometers, etc. made from materials like cocoanut shells. Everybody agreed that they were cheap and best suited for boys in village high schools, provided the boys had enough aptitude for science knowledge. But no one explained how to construct instruments like interferometers with cheap materials. Moreover, even if the colleges and schools were provided with workshops, I don't think people would find time to work there with their already overloaded curricula.

In this summer institute too, the participants were unwilling to sit for an examination; they said they were not students but participants. Though they put forward arguments based on questions of prestige, etc., I agree that the fear of exposing their own weakness was a major cause. But in the test papers there was no emphasis on 'thought' questions. Only the American consultant gave us a paper resembling a quiz. The Indian counterpart presented a paper which in all respects resembled a mathematical physics question paper of an M.Sc. class. I recall a system of 'thought questions' was introduced in the Madras high schools some years back but, for some unknown reason, it was discontinued. When I tried to introduce the system in the weekly tests in my class, the students failed to grasp the significance. They took the tests very lightly and wrote howlers in the answer papers.

The educational films were just filmisation of lectures on specific topics with the showing of complicated and massive instruments producing volumes of graphs. While the college teachers could understand them, the high school teachers were neither able to follow the script nor grasp the meaning of the experimental results. The usefulness of such films to the high school boys and the undergraduate boys will be further limited. In their stead, simple experiments with quantitative results and qualitative explanations would be more easily understood.

The aim of discovering ways and means of teaching students better physics was not pursued at all. Valuable time was wasted in going over the subject at a fast pace and in doing obsolete experiments in the laboratory. The participants working in junior colleges, teaching pre-university or B.Sc. classes, have no chances of using such topics and experiments. Post-graduate teachers, on the other hand, are dealing with these topics and experiments every year. Nothing new was achieved. Further, people who studied wireless or spectroscopy as their special subjects were neither interested in nor could do the electronic experiments.

I feel different summer institutes should concentrate on different subjects like heat, electricity, etc. Then a participant can attend any one of the institutes to learn more of the subject or of the art of teaching it. This arrangement will minimise the organisational difficulties and expenses.

K. N. Ramachandran

Asstt. Professor of Physics,
R.S.G. College, Tanjore

IN THE NEWS

Man Mohan Suri, an Indian engineer who hit the headlines 12 years ago with the invention of the famous Suri Transmission System for diesel locomotives, has now won one more coveted award — The Sir Walter Plucky Indian Prize for " the most significant contribution to production engineering in India ".

At present Director of the Central Mechanical Engineering Research Institute, Durgapur, Suri had joined the Indian railways as an apprentice in Jamalpur in 1945. Within four years he became the Production Engineer at the Jamalpur workshop. After a spell as Assistant Mechanical Engineer at Howrah, he was posted in London (from 1954 to 1957) as a railway inspecting officer with the Directorate General of the Indian Stores Department. It was during this time that he invented and developed the Suri Transmission System which offered an effective solution to the problem of avoiding waste of diesel power in diesel locomotives.

The Prize, instituted to encourage production engineering in India, consists of a medal, a certificate and Rs. 900 in cash. It was presented to Mr. Suri by Sir Walter Plucky himself at a special function held in London recently.

NEXT ISSUE

SYNTHESIS OF GENES IN THE TEST-TUBE by Sankar Mitra

NUCLEAR ROCKETS by H. P. Mama

THE NEW MANAGERS by N. Seshagiri

THEY MISSED THEIR CHANCE by Badiuddin Khan

Also SLEEP LEARNING, ELECTRIC CARS, and the usual features

SCIENCE SHAPES LIFE

UNKNOWN ENERGY

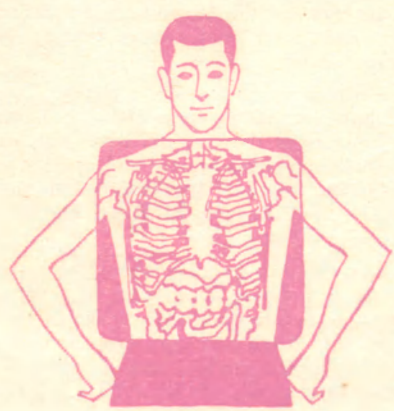
Two astronomical puzzles, the strange radio emissions attributed to " mysterium " and the extremely intense infrared objects that have been discovered recently, may really belong to the same class. The big question, however, is: What are they?

These objects which seem to lie within our galaxy seem to be generating far more energy than considered possible for a star. Astronomers speculating on possible sources for this energy advance three theories: 1. They are new stars being formed. 2. They are stars undergoing disruptions of a kind never before observed. 3. They are the creations of distant supercivilisations. Such supercivilisations were postulated in 1960 by Dr. Freeman J. Dyson of the Institute for Advanced Study in Princeton, USA.

FLUOROSCOPE FREEZE

The television " stop-action " technique on the football field has been extended to the losing coach's ulcer in the medical clinic.

Doctors can now " freeze " any image in fluoroscoping the patient. Fluoroscopy is the continuous X-ray viewing of the body, a moving picture of bones and soft tissue.



The new system permits the doctor to study the X-ray image for as long as he chooses without adding any radiation input to the patient's body. Doctors say it can reduce by 10 times a patient's exposure to X-rays during a typical fluoroscopic examination. The new equipment was developed by Westinghouse Electric Corporation, USA.

THE TALKING COMPUTER

A calculator invented by a New York lawyer-engineer Walter H. Stenby answers when spoken to. The robot machine is designed to listen to a voice-delivered problem, figure the result and announce it orally.

The announcer arrangement represents an improvement over apparatus Mr. Stenby patented in 1965, which was speech-controlled but responded in visible figures, having no voice of its own.

The arithmetic is done by a standard 10-key calculator. To strike the digit 1 (one), the operator really pronounces into the microphone three phonetic sounds : w, u and n.

The command for the figure eight, for example, sounds like " aid," and the code avoids confusion of the " s " sound with " th " and " z ". After the figures are in, a command to add, subtract or multiply may be given.

FERTILISER HAZARD

Biologist Barry Commoner has warned that growing use of inorganic fertilisers is creating a serious health hazard particularly for infants. Dr. Commoner noted that the nitrates in the fertiliser can become concentrated in foodstuffs, including certain baby foods. These nitrates react with intestinal bacteria in such a way that they can, if sufficiently concentrated, lead to respiratory failure and even death. Infants, he noted, are particularly susceptible, due to the nature of the bacteria.

BRAINY BIRDS : BIRD BRAINS

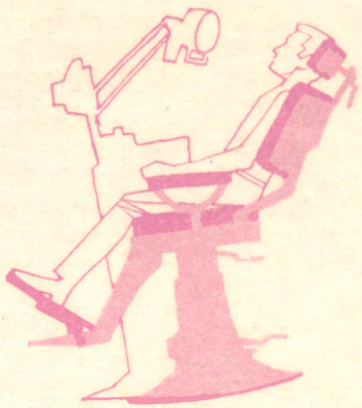
We've heard about a crow who used to wait where a fisherman had put down lines. When a fish was hooked, the bird flew to the line, took it in its beak and walked backward to pull in a length of line. Holding the line down with its feet, it walked forward and grabbed more line. Eventually, it got the fish up to the surface.

An unusual feat for a crow? Not really. Crows and ravens, too, are the geniuses of the bird world. Parrots, sparrows and titmice also show signs of unusual intelligence. But they are exceptions. Most birds have little learning ability compared to mammals.

Crows have learned to rouse their masters, call their names and go to the refrigerator for food. There are plenty of tales of crows' accomplishments. Scarecrows rarely scare them and the big black birds can even do simple arithmetic. If two men walk to a bird-watching blind and one leaves, most birds think both have left and resume their normal activities. Crows, however, seem to realise that one man has remained behind.

THE ELECTRIC DENTIST

Can't tolerate the dentist's needle when he injects novocaine ? Try a little electricity.

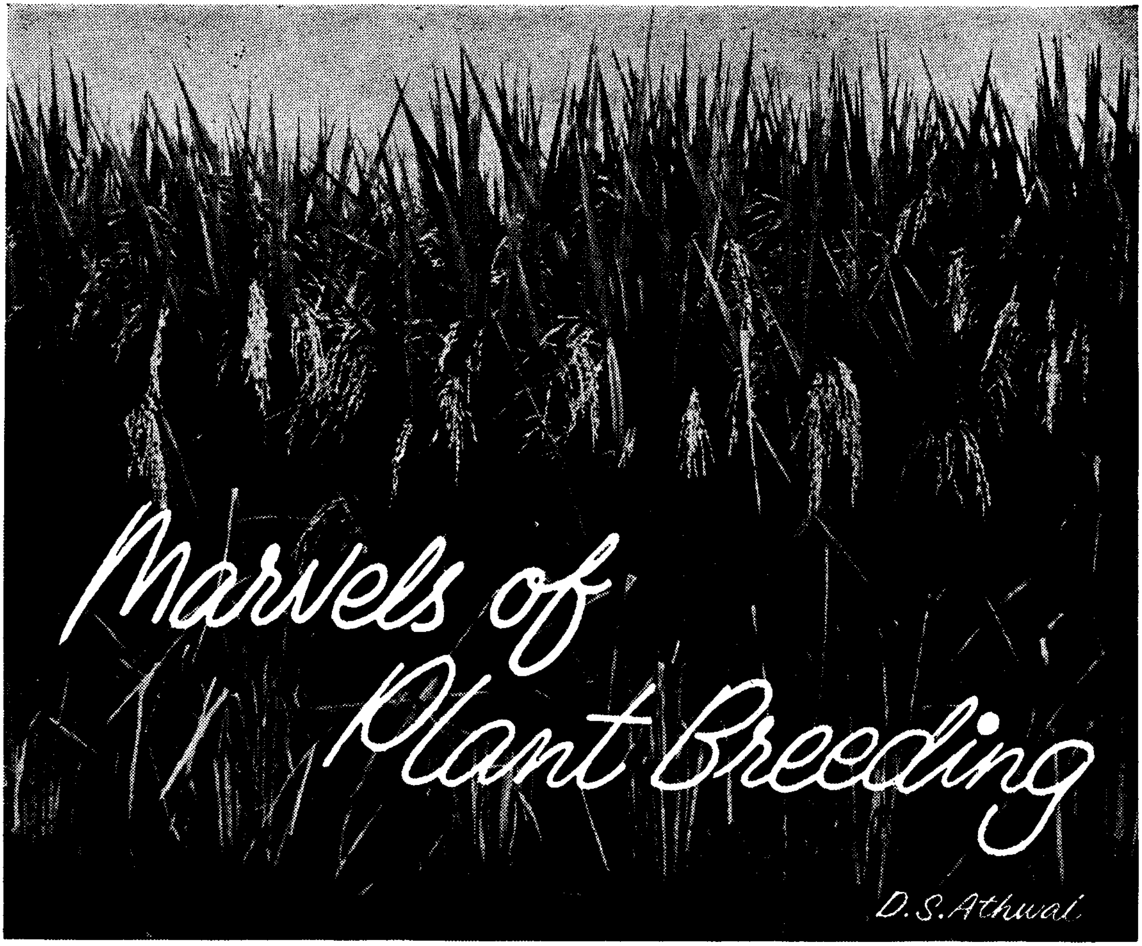


Sedative effects are obtainable in anxious patients by running an alternating electric current of low milliamperage through the brain as the patient sits in the chair. The current is introduced via electrodes placed over the eyes and at the back of the head.

" Patients are conscious, in full control of their reflexes and able to respond verbally at all times," says Dr. Sylvan M. Shane of Boston, USA. " They are mentally and emotionally relaxed to a degree attainable in the past only by use of sedative drugs administered intravenously or intramuscularly."

Electric currents through the human brain have been applied many times in the past for the purpose of inducing sleep, treating psychiatric patients and providing anaesthesia for surgery.

The Russians have reported recently on their work with light " electrosleep ", pointing out that one or two hours are equivalent to seven or eight hours of natural sleep.



Top: Miracle rice IR-8

ONLY three years ago, the farmer in India did not believe that it was possible to attain for wheat an yield level of 3 metric tons an acre. Today, he is not only convinced that it is possible, but is prepared to project that the future yields from his land would be substantially higher. What brought about this revolutionary transformation in the attitude of the Indian farmer, known for his diffidence and skyward look? Perhaps the most important factor responsible for this is the discovery of " hybrid vigour " in crop plants bred by new scientific techniques.

Plant breeding by itself dates back to time immemorial; but its development as a science came from the discovery of the laws of heredity towards the beginning of this century. Today, plant breeding depends mostly on the understanding and application of genetics and other basic sciences. What determine the various characteristics of living organisms are their hereditary units called ' genes '. They are carried on the chromosomes located in the nucleus of a cell. As this hereditary material, with its functional potentialities, is passed on from parents to the progeny, unending possibilities of improving the crop plants arise. Improvements can be achieved by recombining variously the desirable characters through hybridisation.

Purpose

The primary purpose of plant breeding has been to develop varieties (hybrids) which are efficient in the use of nutrients, give the greatest economic yield per unit area, and are adapted to the needs of the growers and the consumers. Once the necessary techniques for this became available through modern researches in genetics, it was possible to tailor crops according to human requirements.

Through genetic manipulation, it is also possible to develop crop varieties which are

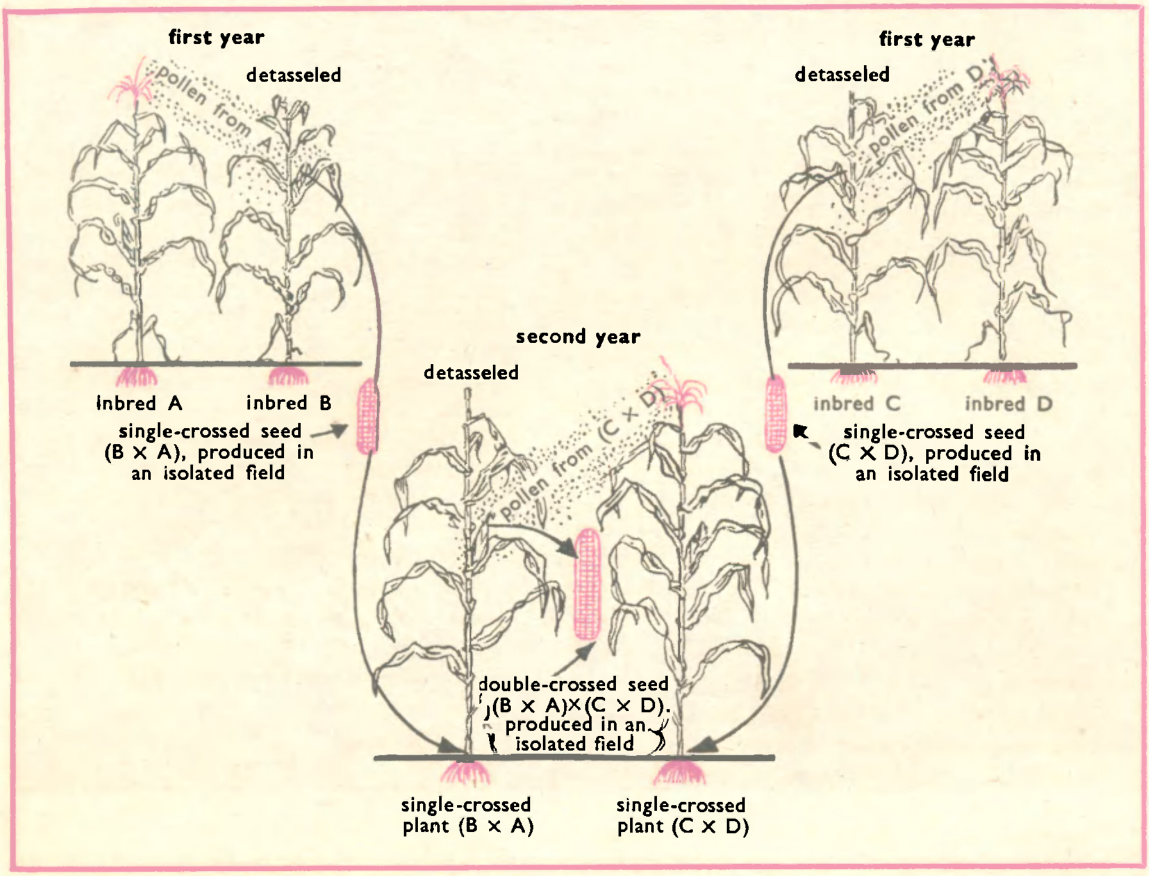


Diagram of crossing inbred plants and the resulting single crosses to produce double-cross hybrid seed

resistant to diseases and pests, have a specific maturity period and are suited to mechanical harvesting. In fact, a plant breeder is constantly endeavouring to reach that theoretical ideal where all the desirable characters can be combined in a single plant variety. Plant breeding represents today a continuous process of creating new varieties to cater for the changing requirements and to withstand the variation in the pathogens attacking plants.

The choice of a breeding method is determined by the plant's pollination system. In self-pollinating plants, the attempt generally is to evolve a pure breeding strain by selecting in the segregated generation a cross between lines possessing the desired characters. In most cross-pollinated crops, it is indeed feasible to develop hybrids or synthetic varieties, and exploit the phenomenon of hybrid vigour for securing higher yields.

Whatever the breeding procedure, the existence of variability in any crop is basic to the success of a breeding programme. In recent years, special attention has been paid to conserve germplasm. Large genetic collections, or 'gene banks' of most crop plants are now available. The plant breeder draws upon these 'gene banks' for the genes he requires to be transferred to a cultivated variety. New breeding techniques and means for increasing the variability are also being continually discovered. Chromosome transfer, and gene and genome mutations by chemical treatment and irradiation offer new breeding and improvement opportunities.

Dramatic increases

In a majority of research projects, the plant breeder has been content with a gain of about 10 per cent in the yield of a new crop variety developed over a period of several years. However, there are instances of major breakthroughs. One is the discovery of a hybrid corn in the USA which doubled the yield potential of this crop. Working independently, East and Shull had found that continued inbreeding in maize led to a loss of vigour, but hybrids between selected inbred lines were highly productive. A new era in maize breeding began when Shull suggested a method for the production of hybrid seed.

Soon after this, in the early thirties, the United States started commercial cultivation of maize hybrids. The success it attained stimulated considerable interest in the use of this breeding method for sorghum and other crops also. Thanks to these developments, commercial cultivation of crop hybrids has made a significant contribution to increased production.

Dwarfs

Development of dwarf wheat and rice varieties is another feat of plant breeding which has revolutionised foodgrain production. During growth and development, the plant accumulates dry matter through photosynthetic activity. In foodgrain crops, that part of the dry matter which is accumulated in the form of grains constitutes the economic product. Excessive vegetative growth is not necessarily associated with high grain yield. The tall growing varieties are in fact incapable of responding to a high level of soil nutrients. They fall over under luxuriant growth conditions and, in spite of the abundance of all other factors contributing to higher yield, become a limiting factor in production. The discovery of dwarfing genes provided a genetic tool for changing the plant frame.

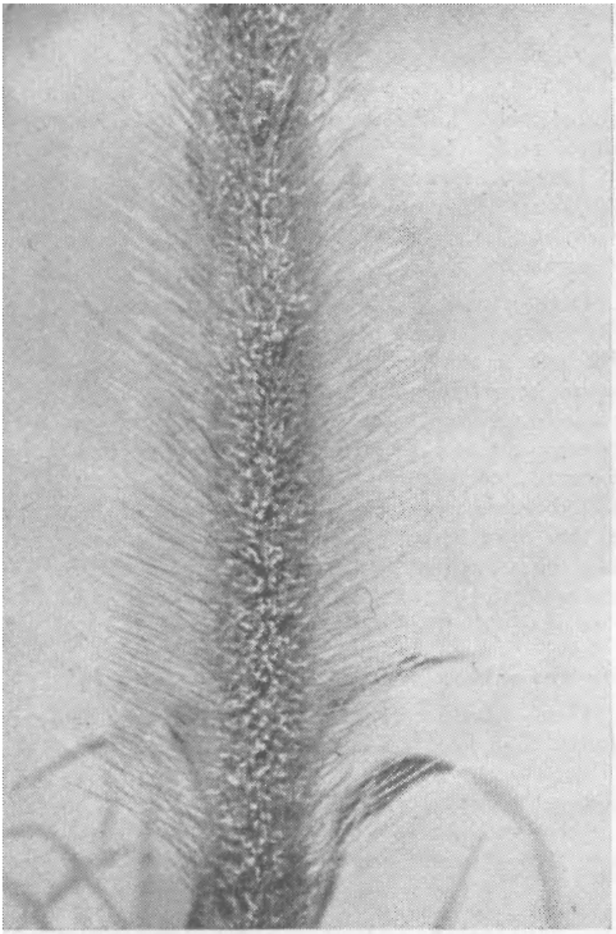
This came about two decades ago. The Norin wheats of Japan were discovered to possess genes capable of reducing the plant height and Vogel in the USA and Borlaug in Mexico soon initiated work on combining these genes with other desirable features. Their pioneering researches led, in the last decade, to the development and release of high-yielding dwarf varieties of winter wheat and spring wheat respectively. These varieties respond to heavy doses of fertilisers and have produced grain yields far in excess of anything previously heard of. Dwarf Mexican wheats have established new yield records in several countries of South America and Asia.

Development of high yielding dwarf varieties of rice at The International Rice Research Institute in the Philippines is an equally sensational achievement. Five years ago some *indica* varieties of rice from Taiwan were found to possess a single gene for dwarfing. The first variety incorporating this dwarfing gene, released recently by the Institute, has been hailed as the ' miracle rice '. The single step of combining the dwarfing genes with other desirable characters in commercial varieties of wheat and rice nearly doubled their yield potential.

Recent achievements in India

Plant breeding research has not lagged in India. The food crisis during the last decade

A dwarf line of *bajra* with long ears



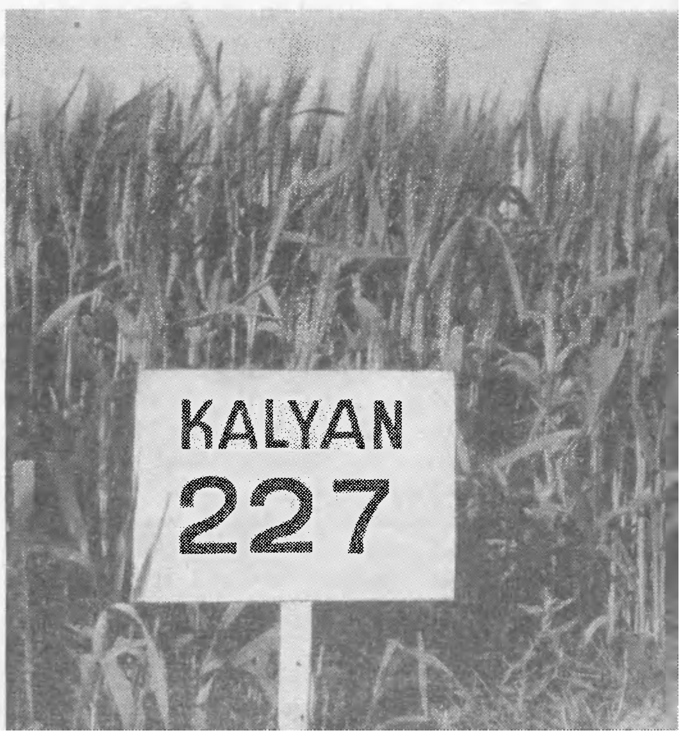
A *bajra* ear with bristles which provide genetic protection against bird damage

greatly accelerated the research in this field. Several hybrids of maize and sorghum have been developed under the All-India Coordinated Research Projects and released for commercial cultivation. Wheat, rice and *bajra* (pearl millet) are the other crops in which new varieties, introduced or developed locally, have resulted in a major breakthrough in production. As the author was associated primarily with wheat and *bajra* research at the Punjab Agricultural University, it is the purpose of this article to review the advances made in these crops in relatively greater details.

In November 1963, Mexican wheat material comprising four commercial varieties and a large number of progenies of crosses in different generations became available through the courtesy of the Rockefeller Foundation for evaluation under Indian conditions. In all-India coordinated yield trials, two of the Mexican wheats, namely Lerma Rojo 64A and Sonora 64, demonstrated high yield potentials and these were released for cultivation in 1965. The evaluation of advance generation lines of crosses, also obtained from Mexico, led to the isolation of strains even superior to the commercial Mexican wheats. Several new strains were selected from this material at the Punjab Agricultural University and the Indian Agricultural Research Institute and released to the farmers. Among the strains which aroused unusual enthusiasm was the Kalyan-227. It increased the yields several fold.

New strains, developed by crossing lines of Mexican origin with the local wheats, combine short stature with excellent grain quality and have yielded quantities of wheat even higher than Kalyan-227. But the best is yet to come. Some of the breeding stocks being utilised in crosses have broad, erect and dark green leaves capable of very efficient synthesis of food from the raw material at their disposal. Others have long heads with a large number of fertile florets per spike. There are still others which are very short and possess three dwarfing genes. With the known laws of heredity, it is possible to breed

Dwarf wheat Kalyan-227



a variety still shorter than the present cultivated ones and loaded with numerous heavy heads. The seed of the newly developed triple dwarf lines which are highly resistant to lodging is now being multiplied for extensive trials.

Such high yielding, fertiliser-responsive rice varieties as IR-8 (the 'miracle rice') marks a new era in the cultivation of this crop in India. The first lot of seed imported for trials during 1966 multiplied and spread very fast. And the concept of an efficient plant type with dwarf stature and short, erect leaves has provided a new stimulus to rice improvement research.

Hybrid *bajra*

In spite of the importance of *bajra* as a food crop, it did not receive adequate attention in the past. In India, it is grown over an area of nearly 28 million acres. But initial efforts at exploiting the phenomenon of hybrid vigour having failed, for many years it was given up as a difficult crop. The intensive research carried out at the Punjab Agricultural University, Ludhiana, in cooperation with the All India Coordinated Millet Improvement Project, led to the development and release in March 1965 of the first commercial hybrid which has shown the way of doubling the yield.

How was this breakthrough achieved? Unlike maize, the male and female flowers of *bajra* are borne on the same inflorescence. This makes it impossible to emasculate the plants on a large scale for the production of hybrid seed. The prospects of producing hybrid seed brightened in 1961 when a cytoplasmic male sterile line was discovered at Ludhiana.

In the following year, the seed of another male sterile discovered earlier at Tifton, Georgia, USA also became available for utilisation in the breeding programme. A male sterile line is one which produces sterile pollen. For grain formation, such a line depends entirely on the supply of pollen from normal plants. The male sterile line can be perpetuated for future use by crossing it with another line, called 'maintainer'. But, for the production of hybrid seed, it has to be crossed with a 'restorer' line, which will restore fertility of the hybrid seed when grown commercially. Such restorer lines, which supply pollen for the production of hybrid seed, are selected from hundreds of lines on the basis of the yielding ability of their crosses with the male sterile line.

A newly developed triple dwarf line of wheat

The cytoplasmic male sterility furnished a practical mechanism for commercial production of hybrid seed. Many hybrids grown in the beginning of 1963 were observed to possess a tremendous amount of hybrid vigour. Once the potentialities of cytoplasmic male sterile lines had been recognised, this led to a major change in the breeding procedures.

Efforts were now concentrated to develop hybrids for commercial cultivation. Research work was expedited by advancing three generations of the breeding material in a single year. Several hybrids based on cytoplasmic male sterility were included in yield trials in the Punjab in 1963. The best amongst these excelled the check by a margin of 62 per cent in grain yield. Adequate quantities of seed of this hybrid as well as two new hybrids were produced for all-India coordinated trials in 1964. The best hybrid evolved by mating the US male sterile with a locally developed restorer line yielded on the average 100 per cent more than the

A field of Hybrid *Bajra* No. 1

previous varieties grown in different parts of the country.

In view of such an outstanding performance, this hybrid was released immediately for commercial cultivation throughout the country and was christened Hybrid *Bajra* No. 1. In 1966, a record yield of 2·7 tons per acre was obtained from this hybrid on a farmer's field in Haryana. This is nearly 20 times the average yield of *bajra* in India.

Discovery of the two cytoplasmic male sterile lines at Ludhiana has a great significance for future breeding programmes. These two lines have been found to be entirely different from the US male sterile in their cytogene mechanism. Majority of the inbred lines, which were incapable of restoring fertility to the US male sterile, possess genetic factors for restoring fertility to the Ludhiana male steriles. These male sterile lines, therefore, offer unlimited scope for the development of future hybrids by utilising a wider range of material. Several dwarfing genes are now available for the production of dwarf hybrids. In future hybrids, the plants will be shorter and highly responsive to fertilisers. The bristles will be incorporated in their earheads to give protection against birds.

Big challenge

A big challenge to the plant breeder, however, is the problem of stabilising the production of new high yielding crop varieties by providing genetic protection against diseases and pests. It is difficult to project precisely the future advances in crop improvement. What is certain is that increases in food production will have to be realised more through higher production per unit area than expansion in acreage. This will necessitate the breeding of still higher yielding varieties.

The spectacular advances in genetics will no doubt contribute to further breakthroughs. Just as the present-day varieties are vastly different from those of the past, the future plant types are likely to be still more different. Though the production potential of an ideal gene combination in a particular crop cannot be predicted, it is believed that the exploitation to-date of variability in most crop plants has not taken us even near the maximum productivity that is possible. Apart from the countless genetic factors awaiting to be explored in germplasm collections, new techniques will be discovered to generate variability or to facilitate gene transfer among distantly related species. The development of methods for producing directed hereditary changes or for controlling the regulatory systems in the synthesis of organic substances in plants may offer possibilities which it is difficult to visualise at this stage.

HEART TRANSPLANT IN BOMBAY

IT was the blaring headlines in the morning papers of 3 December last year that really started it. Dr. P. K. Sen and his associates at the KEM Hospital, Bombay stared at the news item in disbelief. A surgeon in South Africa, Dr. Christian Barnard, had at last dared and carried out history's first homo-graft human heart transplant.

For over 14 long and patient years Dr. Sen and his associates had been perfecting their technique with experimental heart-transplantation on dogs. They had operated on 225 of them so far and kept track of developments in Russia, the USA and other countries, studying any new techniques, and improvising on them back home.

They had gone through the mill all the way. It began with experiments to keep the excised dog heart alive outside the cadaver by super-cooling. Next they grafted another heart in the neck of their canine patients and kept some of them alive for 10 to 15 days. And when the heart-lung machine came, they carried out total heart transplantation in dogs with technical success.

But they had still not been able to dare it on a human being.

It is not that a clinical heart transplant was altogether unexpected. Three weeks ago another leading surgeon, Dr. Norman E. Shumway of Palo Alto, California, had remarked suggestively: "We are on the verge of clinical application." He had just developed the "atrial stump" technique of attachment. And a few weeks later he did attempt one, though unsuccessfully, on 6 January.

Given thorough preparation in animal surgery and the development of mechanical aids and supportive procedures, technical successes in human heart transplantation have for some time been considered attainable, the degree of success depending in each case on the skill, general medical sophistication and daring of the particular surgeon and his team.

When Dr. Sen and his team of 35 surgeons and technicians attempted their first ever heart transplantation last February, they could be considered to possess not only the attributes mentioned above, but also the sheer physical stamina to carry it through successfully.

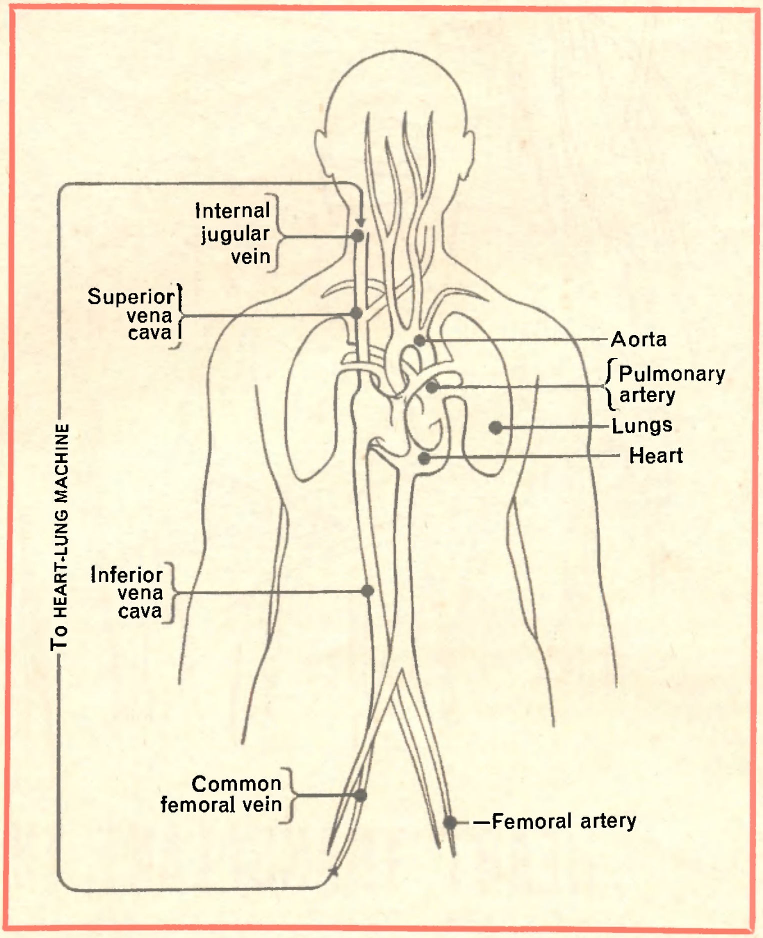
The operation

THE man on whom the world's sixth heart transplant was tried was Bodhan Chittan, a 27-year-old Rajasthani immigrant to the city. Bodhan had come to the KEM Hospital six months back. He was suffering from a chronic disease of the heart muscle, in which the muscle gets replaced by fibrous tissue. The heart doesn't contract effectively and therefore fails in its main function as a pump. The hospital physicians gave him up as a doomed case and transferred him to the surgeons. As his condition was deteriorating rapidly, the surgeons in consultation with the heart physicians decided that his only hope of survival was through a transplanted heart.

When the matter was put to Bodhan, he readily agreed. He was willing to gamble his all, whatever the risk, if it could help him snatch a few more moments of dear life.

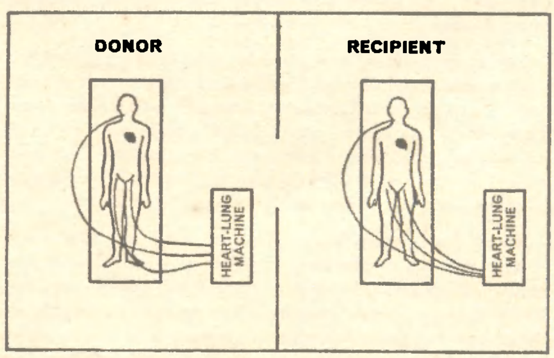
Once the consent had been given, things at the KEM Hospital surgery started moving with clockwork precision. The entire team was put on transplantation alert. Bodhan's blood group was tested and typed as O Rh positive. A call

(contd. on page 20)



Above: The main circulatory system of the body. The connections of the heart-lung machine bypass is also shown (left)

Below: The twin theatre



The human heart

POETS have invested the human heart with many noble qualities and emotions. But essentially it is just an efficient and delicately balanced pump which maintains the normal blood circulation systems in the body.

The heart is situated in the midleft portion of the chest. It is covered by a two-layered, thin-walled sac, called pericardium. A small amount of tissue fluid between the two layers helps the beating heart to move without friction.

Strictly speaking, the heart is not a single

The donor's heart being brought to the recipient

unit. Anatomically and functionally, it consists of two isolated pumps, called the 'right heart' and the 'left heart'. The right heart receives blood from the veins of the entire body and pumps it into the lungs where the blood gets oxygenated by the inhaled air. This oxygenated blood then enters the left heart via the pulmonary veins (veins which bring oxygenated blood to the heart) and is pumped throughout the body via the aorta and its branches (chief suppliers of blood to the whole body).

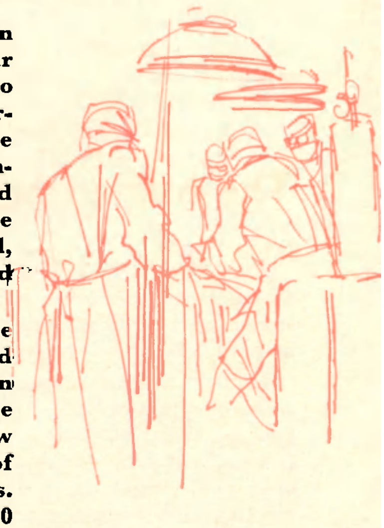
The right and left hearts themselves are made of two chambers each, connected by one-way valves. The upper chamber is called the 'atrium' and the lower one, the 'ventricle'. The valve connecting the right atrium to the right ventricle is called the tricuspid valve; that of the left heart is known as the bicuspid or mitral valve.

The heart and the circulatory systems function in the following way: Blood is returned from the body to the heart by the large veins; the one that transports blood from the legs, thighs (femoral regions), the abdomen, and the chest is called inferior vena cava; the other which collects blood from the neck (jugular region) and the head is called superior vena cava. Each of these veins empties into the right atrium.

Both the right and left atria have a musculature which easily adapts to the quantity of incoming blood. Blood pours into them when the heart muscles relax. The atrio-ventricular valves (tricuspid and mitral) open and blood flows passively into the relaxed ventricles.

The two ventricles work in unison, both discharging their load of blood simultaneously into their respective outlets, or arteries. This phase of the heart cycle — the expulsion of blood by contraction of the ventricles—is called systole. The phase in which the ventricles are filled with blood, each from its own atrium, is called diastole.

Systole is followed by diastole (relaxation) and the ejected blood in the arteries of the lungs and in the aorta try to return to the ventricles. But the backward flow is prevented by the closing of the pulmonary and aortic valves. The cycle repeats itself 65 to 90 times a minute throughout one's normal life.



was sent out to voluntary bodies to collect this group of blood. By the end of the day, the students and surgeons themselves had donated twenty litres of it and kept ready for transfusion. They were now only waiting for a suitable heart donor to arrive.

On 16 February, a 19-year-old girl, Lalita Balkrishna, was admitted to the hospital at 2·35 PM. She had suffered extensive brain injuries in a railway accident and was in an unconscious state. The neurosurgeon on duty, after a thorough examination, declared that she had no chance of survival. When it came to the notice of the heart transplant surgeons, they considered her a prospective donor. Her blood group was also O Rh positive, and her heart was normal.

The 35-member surgeons and technicians team now divided itself into a number of groups, under the overall supervision of Dr. P. K. Sen. One group was to look after the donor; the other was to attend to Bodhan Chittan, the recipient; and a third one was to manage the other technical problems.

At about 10·30 PM as Lalita's condition began to deteriorate rapidly, she was wheeled to an operation theatre adjacent to the main theatre. There, first her artery and vein of the right thigh and leg (femoral regions) and then the right internal vein in the neck (jugular vein) were dissected and kept open. This was to facilitate subsequent insertion (cannulation) into these blood vessels of tubes connected to the heart-lung machine. The heart-lung machine bypass is meant to take over the body's heart and lung functions — gathering oxygen-poor blood from the body, replenishing it with needed oxygen and then returning the oxygen-rich blood to the blood stream.

Bodhan too was wheeled into the main operation theatre, was anaesthetised, and his left common femoral artery, right femoral vein and right internal jugular vein were opened and kept ready for venous cannulation. A heart-lung machine was kept ready.

In the other theatre, Lalita's blood pressure was falling steeply. Another half an hour and her heart stopped; her cardiogram showed no signs of electrical activity. The crucial moment had come.

Lalita was quickly administered heparin, a drug which prevents clotting of blood. Her right common femoral artery was first cannulated, then the right femoral vein, and after that the right internal jugular vein. The venous and arterial lines were joined together and she was temporarily put on a partial bypass—to prevent her heart from deteriorating from lack of oxygen.

The donor team then with a few bold strokes opened her chest and pericardium vertically, by first cutting the breast bones. They clamped the main veins (superior and inferior cavae), put the girl on total bypass, and excised her heart rapidly, taking long lengths of aorta, pulmonary artery, and the atria. They next discontinued the heart-lung machine and put the excised donor heart in a stainless steel bowl containing an electrolyte solution cooled to 4°C.

The donor heart was quickly carried to the main theatre where it was perfused with cold blood through an extra arterial line inserted directly into the cut end of the aorta. The heart began to contract; it was ready for transplantation.

All this time the recipient team in the main theatre had been similarly active. They opened Bodhan's chest the same way, by cutting his breast bones and pericardium vertically; dissected his aorta, the main pulmonary artery and both the venae cavae; and then heparinised him. After that they cannulated his left common femoral artery and the right femoral vein, followed by the superior vena cava, joined the venous and arterial lines together and put him on bypass. And just before the donor heart arrived, they cross-clamped and divided Bodhan's aorta close to the left ventricular flow tract, divided his pulmonary artery and then excised first his right atrium and next the left atrium, leaving sufficient lengths of aorta, pulmonary artery and the atria. The diseased heart was then removed.

The donor heart was now taken out of the bowl, placed in the pericardial cavity of Bodhan's chest, and measured for any adjustments. After the stumps had been trimmed to size, the aorta of the donor heart was joined to the aorta of Bodhan by Mersiline, a synthetic suturing material. Suturing over, the clamps on Bodhan's aortic stumps were released. It started coronary circulation of the transplanted heart which began contracting with a normal rhythm.

To facilitate further suturing, the heart was stopped (fibrillated) by means of an electric shock. The interatrial septum (diaphragm separating the two atria) was sutured, followed by the right atrium, then the left atrium, and finally the pulmonary artery of the donor to that of the recipient. As the heart had resumed normal rhythm, the fibrillator wires were discontinued. Air was removed from both the right and the left ventricle and also from the aorta.

The time was 2·15 AM, 17 February 1968—two hours since the suturing of the first blood vessels had started. It had been a deft and quick surgery. There was no bleeding from any of the sutured

HEART TRANSPLANTS TILL 20 MARCH 1968

Patient	*Date & Place*	*Donor*	*Surgeon*	*Results*
1. Louis Washkansky (55)	3–12–1967 Capetown	Miss Dennise Ann Darvall (24)	Dr. Christian Barnard	Died on 21–1–1968 18 days after the operation
2. A two-and-half week old child	6–12–1967 New York	A 2-day-old baby	Dr. Adrian Kantrowitz	Died after 6½ hours
3. Dr. Philip Blaiberg (58)	2–1–1968 Capetown	Clive Haupt (24)	Dr. Christian Barnard	Alive and progressing well
4. Mike Kasperak (54)	6–1–1968 Stanford, California	Mrs. Virginia Mae White (43)	Dr. Norman Shumway	Died on 21–1–1968 15 days after the operation
5. Louise Block (58)	10–1–1968 Brooklyn	Helen Krouch (29)	Dr. Adrian Kantrowitz	Died same day after ten hours
6. Bodhan Chittan (27)	17–2–1968 Bombay	Lalita Balakrishna (19)	Dr. P. K. Sen	Died after 3 hours

lines. But would the new heart support the circulatory system?

Hopes at this stage among the masked men and women around the operation table at KEM Hospital had run high. The transplanted heart was beating vigorously and it seemed it had taken to its new site rather enthusiastically. When the bypass was removed and the vents were clamped, the blood pressure registered 110/80 and the pulse 90 per minute.

But after fifteen minutes, though the left ventricle was contracting vigorously, the right ventricle of the heart began to give way. The patient had to be supported again by heart-lung machine. He was administered a drug; he improved and was again taken off the bypass. But after a few minutes right ventricular distension recurred, and continued intermittently. Despite all the efforts, the cause of failure could not be overcome. Three hours later the transplanted heart gradually came to a stop.

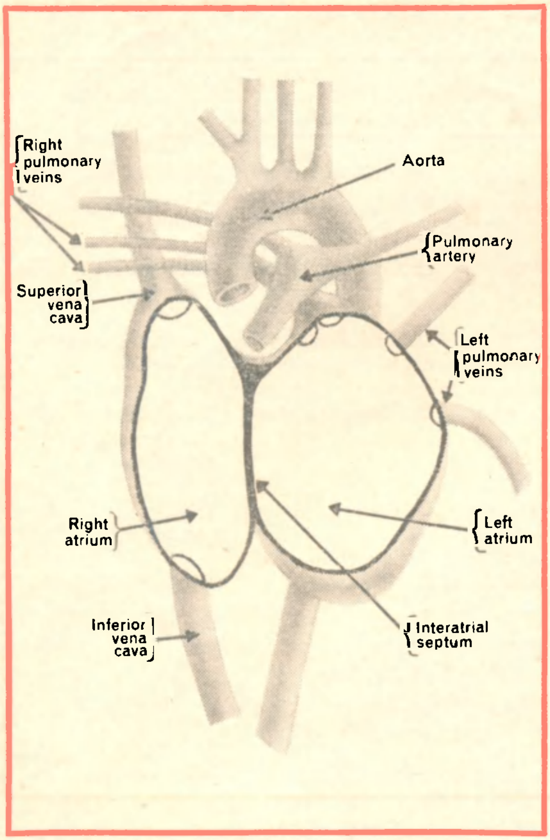
The genetic barrier

FOR any transplantation surgery to be successful, two different kinds of problems have to be solved. The first is the surgical technique; the second, overcoming the rejection mechanism. The first has already been fairly established. The second is the more critical and yet unsolved, mostly due to insufficient knowledge. It is the problem of histocompatibility, suppressing the immune barrier (see SCIENCE TODAY, October 1967).

Immune reactions form a part of the defence mechanism in the body, directed mainly against infectious diseases. When a germ or some other foreign substance (antigen of a foreign cell) enters the blood, the white cells immediately start to fight the invader by manufacturing antibodies. And each antigen needs a different protein antibody to act as counter poison.

Immune mechanism has been overcome by subjecting the patient to a massive dose of X-rays, or by treating him with drugs like azathioprine (Imuran), cortisone and alkylating agents. They have a completely neutral reaction to both the tissues and other organisms. For this reason, they also expose the patient to the dire peril of picking up every infection going around. Louis Washkansky, the first heart transplant patient of Dr. Barnard, perhaps died because his body was rendered open for such attack by an overdose of anti-rejection treatment. He probably contracted pneumonia.

Immune reaction is also perhaps important in the elimination of cancer cells. And any treatment which suppresses it leaves the patient open to both infection and, probably in the long run, to cancer (unless it suppresses specifically the ability to produce a limited array of antibodies).

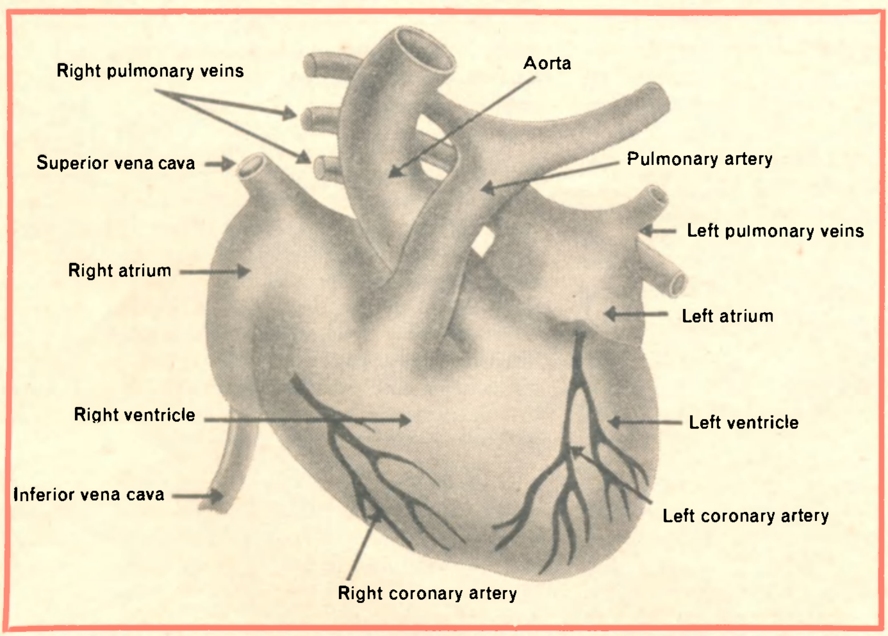


The genetic barrier . . .

More attention is being paid now to certain immunosuppressive drugs known to show greater selectivity in their action. One is antilymphocyte serum (ALS) which seems to act mainly on lymphocytes in the blood stream, and consequently damages only part of the lymphoid apparatus. The damaged part is responsible for the cellular type of immunity which works against grafts. Those cells which manufacture antibodies dealing preferentially with bacteria and viruses are spared.

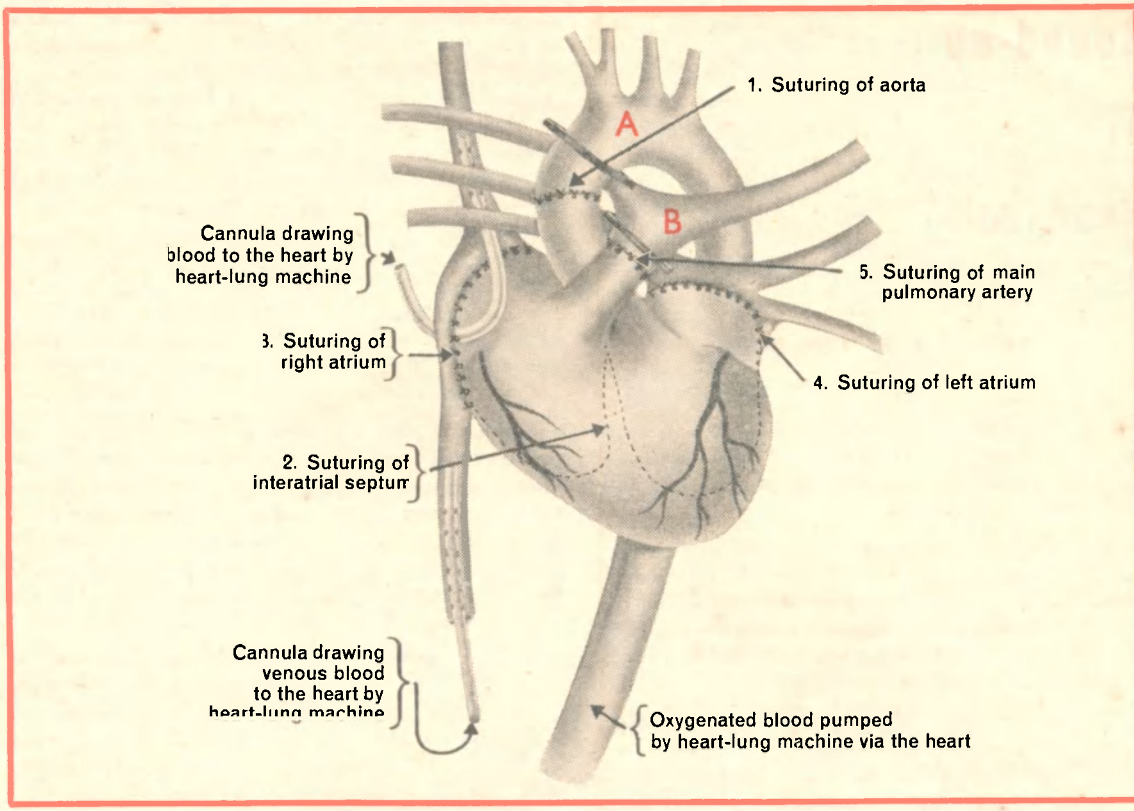
The immune reaction need not arise where the donor has no antigens that the recipient lacks; for example, in the case of identical twins. But in other cases, histocompatibility barrier can be reduced by tissue typing (analogous to the typing of red blood cells for transfusion). Matching of transplantation antigens can be done by detecting individual leukocyte antigens with suitable isoimmune antiserums (leukocyte typing) or by the use of matching tests such as mixed leukocyte cultures (MLC typing). The results of both these tests can partially predict success of a transplantation.

Evidence is accumulating that there is a single major histocompatibility genetic locus in man, and that either of these types of tests can detect genotypic matching for this locus. Therefore, if donor-recipient compatibility can be established at least for this major locus, there is hope that minor incompatibilities will be suppressed without heroic efforts.



Top, left: The cavity after the recipient's diseased heart has been removed

Left: The donor's excised heart, before its final trimmings



Above: The new heart is transplanted. The numerals 1-5 denote the sequence of suturing. A & B (in colour) are the clamps placed on the stumps of the aorta and the pulmonary artery of the recipient before suturing began

Below: Operation photograph showing the suturing of aorta in progress. Arrow shows the aortic stump of the recipient after his heart has been removed

Bodhan Chittan

Round-up of Research

THE END OF THE ROPE

IT is the heart's connections with the central nervous system that, under certain circumstances, may result in the heart being prematurely and permanently " turned off ".

And what are the factors that evoke such a response in the nervous system towards the heart? Social tension, lack of hope and feeling of insecurity — much more than organic reasons — discloses Dr. Stewart Wolf of Oklahoma City, USA, after a recent investigation into the subject.

The heart, unlike the lungs, has an intrinsic mechanism to maintain its beat. If it is supplied with oxygen and nutriment, the heart will continue to pump for long periods, even when separated from the body. It is therefore a paradox that sudden death should occur in the well-nourished man who is quite capable of breathing.

In the intact individual, a striking slowing of the heart, and sometimes sudden death due to cardiac arrest, has been shown to occur by a variety of means, including intense noxious stimulation of any part of the body, instrumental manipulation of air passages or manoeuvres such as sudden decompression of the bladder. A striking bradycardia — slowing of the rate of heart beat — may also occur under circumstances of extreme dejection or sudden fright.

Individuals can be trained to breathe very little, and thereby to consume little oxygen. Anand, Chhina and Singh of New Delhi made a classical study of Yogis who stay sealed in coffins under water for several hours (*Indian Journal of Medical Research*, 49, 82, 1961). They found that, associated with the decreased oxygen consumption, a striking bradycardia occurred.

Several years ago, in experiments with rats made to swim to exhaustion, C. S. Richter showed that they died with bradycardia, ultimately amounting to cardiac arrest, rather than from drowning. He caused the rats to die more quickly, even in a matter of minutes, by simply cutting off their moustache hairs, or vibrissae, their principal source of sensory information and their way of relating themselves to their environment. On the other hand, rats removed from the water just before death on one day were able, the following day, to swim about and survive for a much longer time than their litter mates who had never been placed in the water. This experiment proves the survival value of hope and the potentially lethal nature of situations that rob the organism of support from its environment. One step further, the sudden death of ostracised persons in primitive societies — voodoo death — can also be explained as a reaction to loss of hope.

Sudden deaths occurring in civilised society are usually attributed to myocardial infarction, although often enough no significant coronary atheroma, no thrombosis and no necrosis of the myocardium are found. Where it has been possible to monitor the occurrence of death following myocardial infarction, the electrocardiogram has shown cardiac arrest or ventricular fibrillation, or both.

Sudden cardiac death can also be the result of an adaptive manoeuvre, representing the operation of a regulatory process rather than the breakdown of a mechanism. Disability and death may result from fundamentally protective reaction patterns gone awry. Death, at times, is the ultimate solution of a pressing problem or difficulty.

In exploring the psychological factors as they relate to sudden cardiac death, it is appropriate to consider the findings in Roseto, an Italian-American community in Pennsylvania, where not only is the incidence of myocardial infarction in the first five decades of life remarkably low, but so also is the death rate following myocardial infarction in the older age groups. Roseto is a place where the populace is generally obese, where the diet is at least as rich in saturated fats as the average American diet, yet the rate of cardiac death is just half of that in neighbouring American communities or the United States at large. The most striking peculiarity of Roseto is its social structure — it is cohesive and mutually supportive, with strong family and community ties. Because of the concern of the inhabitants for their neighbours, there is no poverty and little crime in Roseto. Data gathered before death among the small number of Rosetans who have succumbed to myocardial infarction indicate that they were, to a large extent, alienated or estranged from the mainstream of their culture.

Thus it appears that some of the elements of voodoo death may be operative in our society today.

NEW IN TECHNOLOGY

Metalliding — A Brand New Technique

A NEW metal-coating technique, called " metalliding ", encompasses the interaction of approximately 50 elements in the periodic table, including all the major structural materials and even the rare earths. Its potential applications range from automobile bumpers to rocket thrusters. The technique was invented by Dr. Newell C. Cook at the General Electric Research and Development Center, New York.

Ordinary metal-coatings can be made by normal electrolytical methods, for instance galvanising of steel sheets with zinc. But in the case of metalliding, an alloy is formed over the material.

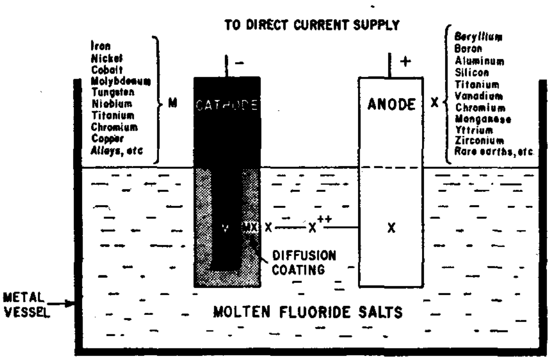
Many of the " alloy coatings " formed by various metalliding processes cannot be created by any other practical method. The new technology makes use of a bath containing molten fluorides.

By means of electrolysis, the fluoride salts serve as a " solvent " to diffuse metals and metalloids, such as boron and silicon, onto the surface of other metals and alloys. The resulting surface compositions offer properties radically different from those of the bulk material.

Molybdenum, for example, is a relatively soft metal that can be scratched by the point of a file. But when boron is diffused onto molybdenum, the resulting boron-molybdenum " surface alloy " is in a class by itself as a bearing surface, and it is claimed to be second in hardness only to diamond.

Similarly, when silicon is diffused into tungsten, rhenium, niobium and molybdenum, it produces a surface with greatly enhanced oxidation resistance. Now, silicon-coated molybdenum parts find high-temperature applications in space-craft, jet engines, rocket motors, arc interruption equipment and heating coils.

ELECTROLYTIC METALLIDING



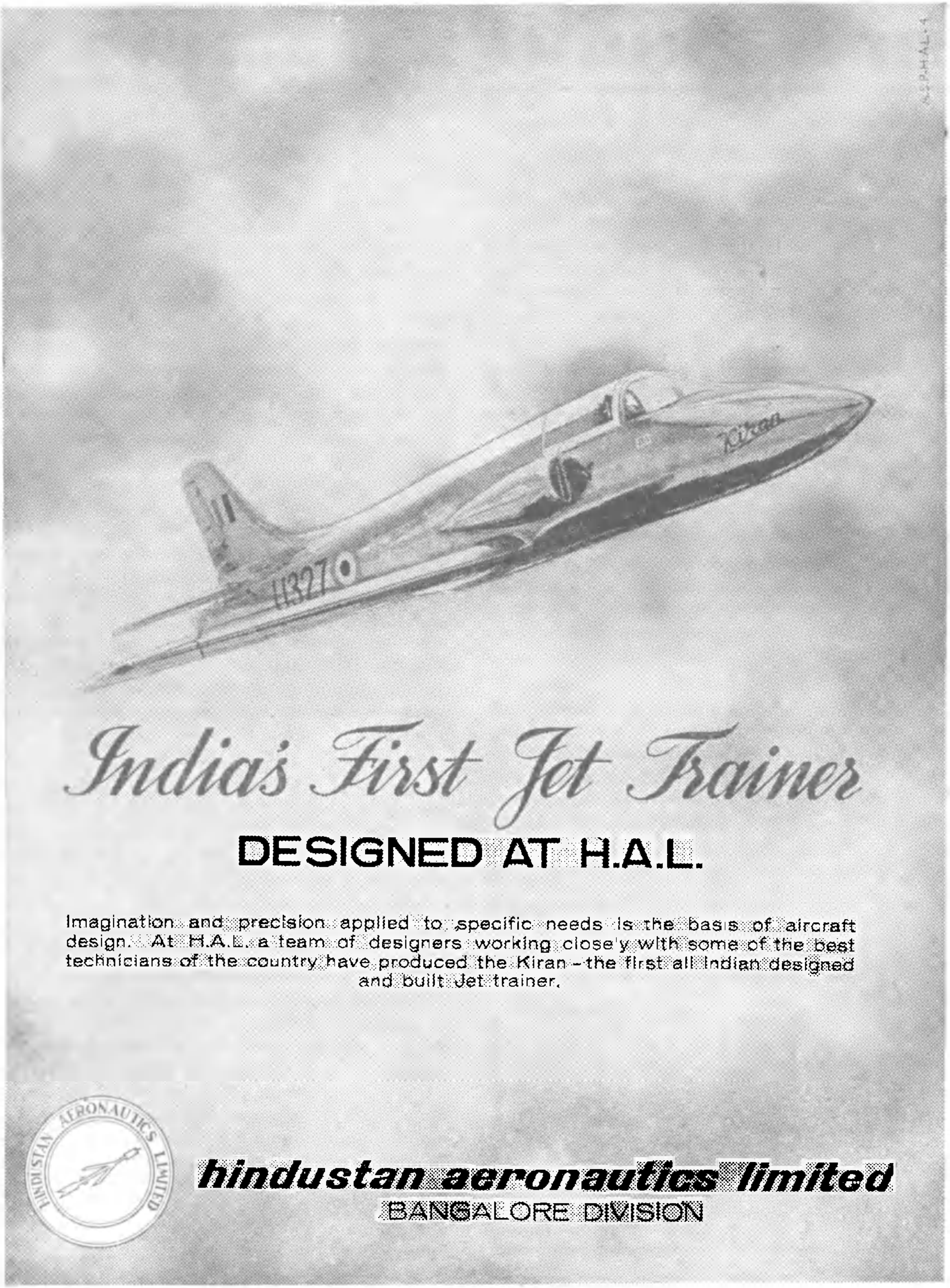
Metalliding is a high temperature electrolytic technique, the temperature ranging from 500°C to 1200°C. An anode and a cathode are suspended in a molten salt bath and as a direct current is passed through the fluoride electrolyte, the anode material diffuses into the surface of the cathode, producing a uniform pore-free coating.

The laboratory-size electrolytic cell (shown in figure) holds 10 to 12 kilograms of molten salt. The furnace is sealed except for a Fibrefrax gasket around the cell so that a gas atmosphere (90 per cent nitrogen and 10 per cent hydrogen) can be maintained in it at all times. Nickel-plated steel covers for the cell are water-cooled and fitted with electrically insulated doors, to reduce radiation losses. Glass electrode towers — with gas inlet tubes for flushing when they are opened — are mounted to the cover plate with silicon rubber gaskets. The salt at 500–1200°C is usually 7 to 15 cm below the cover plate. Automatic regulation of heat, flow meter for gases, and instrumentation for controlling and measuring electrolysis are provided on a control panel. Cells of this type have been used continuously for two years without appreciable wear and tear. Of course, the size of the cell will depend on the type of operation required in a particular context, but basic parameters remain the same.

Metalliding is comparatively an inexpensive and, in most cases, a rapid process. The thickness of the coating can be carefully controlled and continuous processing is now being investigated. In many cases, two different starting materials can be diffused one after the other on to a surface. Although other techniques have been under study for nearly half a century to produce " alloy-coatings " in metals, no method developed to date has approached the versatile scope of metalliding.

Potential applications for metalliding are expected to include the formation of extremely hard surfaces for bearings and dies, the creation of decorative finishes on base metals, and the solving of severe lubrication problems of hard-to-lubricate metals. In addition, these processes can create abrasion and oxidation resistant surfaces on electrical conductors without affecting the gross electrical properties of the material. Many materials can be shielded by means of this process against corrosion and erosion.

O. P. Arya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U327
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CHARLES DARWIN was a dull student, but he had a passion for collecting all kinds of oddities — shells, insects, bugs and what not. His awe-inspiring father once told him: " You care for nothing but shooting, dogs and rat-catching, and you will be a disgrace to yourself and the family." When he proved a failure as a medical student at Edinburgh, his father, convinced that Charles was good for nothing, condemned him to religious education at Cambridge. Here he devoted more time to bug-hunting and insect-collecting than to theology.

Once he found several rare species of beetles running helter skelter as he scrapped an old bark off a tree. He wanted to grab them all and, being short of receptacles, put one in his mouth. But the creature exuded an ' intensely acrid fluid ', and he had to spit it out. It was not long after this that he went on a voyage and, five years later, returned as one of the greatest scientists the world has ever known. His father's predictions had come true: His son had made a monkey of man.

In Lighter Moments . . .

ONCE Isaac Newton invited William Stukley, his first biographer, to dinner. When Stukley arrived he found Newton busy in his study. After about an hour he could wait no longer, and finished his share of the dinner. At last Newton came in and said : " Give me but leave to take my short dinner, and I shall be at your service. I am fatigued and faint." Obviously he had forgotten that he had invited Stukley. Then he moved towards the dining table and, noticing the remains of a meal, said : " See how we studious people are ! I forgot that I had dined."

* * *

HENRY Cavendish was extremely shy of women — even to the extent of being terrified of them. Once he was so much upset to meet a housemaid on the stairs that he immediately ordered a back staircase to be built. To avoid conversation with the housekeeper, his usual practice was to order for meals by placing a note on the table. There seems to be only one record of his conversation with the housekeeper, that too at the latter's initiative. Three or four scientists were to dine with Cavendish, and the housekeeper came to consult him about the menu.

" A leg of mutton ", was the answer. His dinner invariably consisted of only one leg of mutton.

" But, sir, that will not be enough for five ", ventured the housekeeper.

" Well, then, get two ", said Cavendish.

ARE YOU MAKING PROGRESS?

PSYCHOLOGISTS are sure that many people can increase their I.Q. level by constantly working on problems which involve the use of their intelligence. This test is designed to discover if you're making progress.

The quiz is divided into three sections. Simple, hard, and difficult. If you get most marks in the "simple" section, you have about average intelligence; in the "hard" section, you have above average intelligence; in the "difficult" section, you have "super intelligence".

There is no time limit to the test.

SIMPLE

1. Supply the number missing from the brackets in each case:

(*a*) 11(46)12 : 9(. .)19

(*b*) 21(625)46 : 9(. .)31

HARD

1. Given these facts, answer the questions below:

A number of clubs in a city have various facilities. STAG has a bar, stage show and a restaurant. RIVERSIDE has a resident group, bar, stage show and restaurant but no roulette. CELLAR has no resident group but does have a bar, a stage show, and roulette. ATTIC has a bar, a stage show and roulette. DEVONSHIRE has no restaurant but does have a bar, stage show and roulette. MUSICROOM has a group, a stage show and a restaurant, but no bar or roulette.

(*a*) Which club has a restaurant, bar, group, and a stage show?

(*b*) Which clubs run roulette and also have these other facilities?

(*c*) Which club does not have a bar?

(*d*) How many clubs have a restaurant?

2. At a summer camp, 50 boys have enough supplies to last them for 20 days. But after 10 days, another 25 boys arrive unexpectedly. How long will the supplies last?

DIFFICULT

1. Listed below are a number of millionaires, the figures alongside showing their fortune in millions. Say how many millions BAKER and PILGRIM possess:

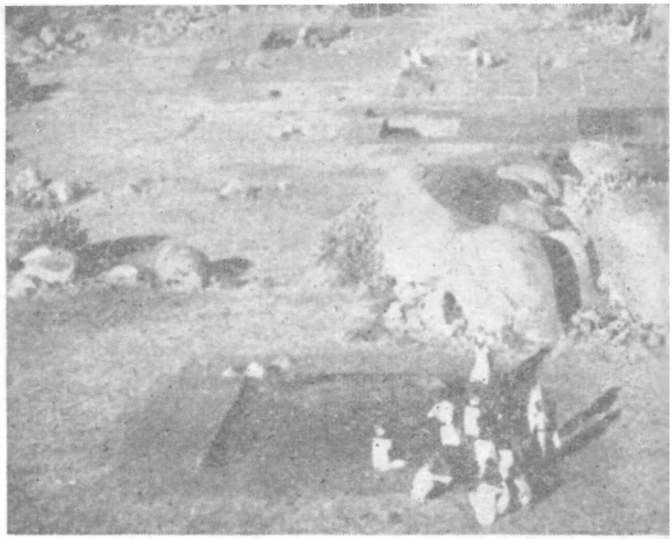
PARKINSON (5) WILLIAMS (4) BARTON (3)
BAKER (?) PILGRIM (?)

2. Find a nursery rhyme in these numbers:
3935478 24312 3 362740403615 363396

(see p. 48)

BEGINNING OF CIVILISATION IN SOUTH INDIA

H. D. SANKALIA



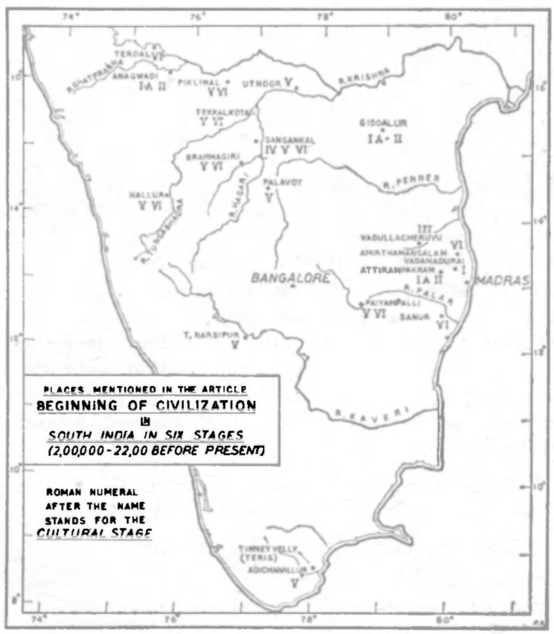
HISTORIANS use the term 'civilisation' primarily to define a stage in the material and cultural development of man, when man had emerged from the stage of food-collection (by hunting, fishing and gathering wild fruits and plants) and had settled down at one place and acquired the art of agriculture, domestication of animals, making of pottery, houses — some of them monumental like temples — fortifications (even palaces) and above all learned the art of writing.

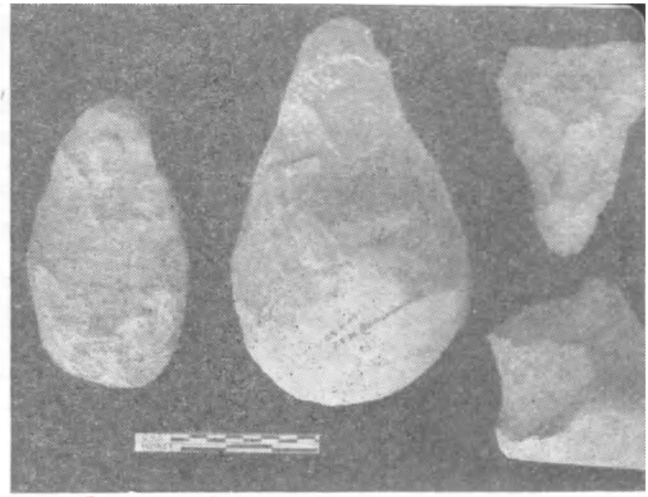
The Vedic and the earliest Greek ways of life or society, for all their richness, heroic deeds and descriptions of gods and goddesses, were regarded as barbarous and not civilised. Even now the UNESCO *History of Civilisation*, following the anthropological definition of civilisation, describes the Vedic period as barbarous or semi-barbarous. As opposed to this, the Indus or the Harappan culture is called the Indus Civilisation, because here for the first time we see not only a well-organised society, but monumental buildings and the first traces of writing.

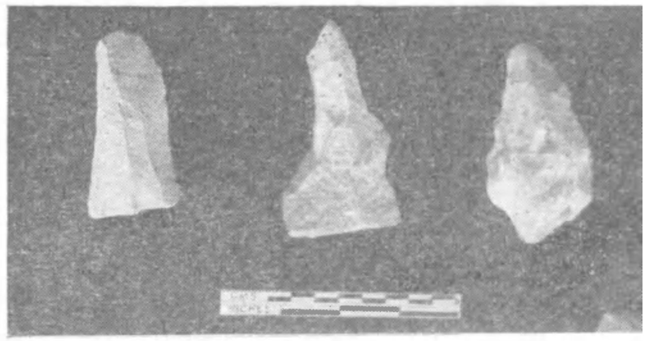
However, one should realise that there are many intermediate stages between preliterate and literate stages of development and also other important criteria in the material and cultural development of man. It is these that we have to take into consideration for understanding the beginning of civilisation in South India.

South India, for at least 2,000 years and more, is understood to be the country south of the Narmada, or, properly, the country south of the river Krishna. This is the ancient *Dakshina-patha*. This definition of South India is not confined to the extreme south, at present included in the district of Tirunelveli or the country included in Tamilnadu. Without further academic discussion, I would include all that country in South India which is geologically the oldest part in India and in the world. This is the area which extends from Raichur in the north to somewhere at Rameshwaram in the south; the coastal tracts on the east and the west are comparatively recent (geologically).

Much of the earliest stages of civilisation in Southern India remains shrouded by a veil of un-







Above: Excavation in progress at a large terrace at a height of 60 metres at Tekkalkota

Above, right: Stage I — crude stone tools and weapons — handaxes and choppers — from Vaddamadurai, Madras (c. 150,000 — 100,000 years Before Present)

Right : Stage II — smaller stone tools and weapons — points and scrapers — from Attirampakkam, Madras (c. 40,000 — 30,000 B.P.)

proved conjecture. However, work carried out over the past 30 years is beginning to throw some light in this direction. The earliest stage is seen not only in and around Madras in the district of Chingleput, where the first tools were found, but in almost all the districts of Mysore and the northern districts of Tamilnad, excluding the far south. In all these areas, we get large, crude stone tools, called handaxes and cleavers, along with pebble tools. Though no animal fossils have been found to date this earliest stone industry, typologically, it may be placed between 1,50,000 and 1,00,000 years before the present.

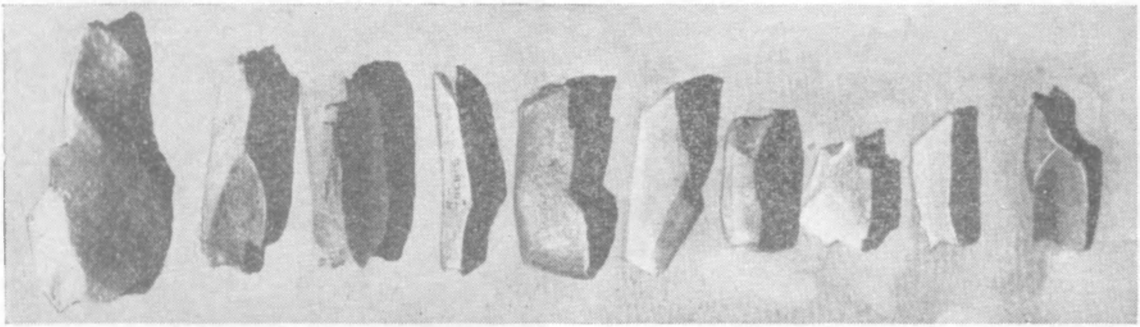
With these heavy tools man could perform some of the most elementary functions and eke out a living. Though we have no evidence of the flora and fauna of this period, we can assume that the climate there at that time was far more humid than it is today ; all the rivers carried huge boulders and these were deposited all along their beds when their carrying power was reduced. In or around Madras, the climate was far more humid earlier, because here we find large deposits of laterite—a brick-like, iron and alumina-rich rock which appears to have been formed on a gently sloping landmass and in a climate characterised by short periods of heavy rainfall followed by long dry periods. If we are allowed to extrapolate the evidence from Maharashtra, parts of Andhra, UP, West Bengal and Madhya Pradesh, we may say that at this time large tusked elephants, wild oxen and three-toed horses and other animals should have been living in South India, and these must have provided food to man.

From the large number of tools found in and around Madras and in many districts of Andhra and Mysore, one might also say that the population at this time was fairly thick and well distributed, spread out along the banks of smaller and larger rivers, and near foothills where raw material was easily available.

How long man remained in this very primitive stage we cannot say. At Attirampakkam, near Madras, at Giddalur (district Kurnool), at Anagwadi (district Bijapur), for instance, we find tools which are comparatively light and beautifully finished showing that this man, though a hunter-fisher, had developed an artistic sense. All over South India, as well as in the North, we observe a definite development in the making of tools which should indicate man's mental development. And this, from African and Western Asiatic evidences, based on Carbon-14 determinations, can now be dated to about 50,000 years before present.

Second stage

What happened to this man is unknown. So far



Stage III — blades and burins from the Rallakallava, near Renigunta, A.P. (c. 20,000 — 10,000 B.P.)

no physical remains of this early man have been found anywhere in India. But we do know that all over South India, beginning with Attirampakkam in the south and extending up to Bijapur in the north, these heavy but finely made tools were given up by man. In Bijapur and in many parts of Andhra, this man had also given up the use of quartzite. He now preferred still better fine-grained rocks. His tools and weapons are much smaller and may have provided him with spear-heads, lance-heads and the variety of scrapers used for smoothing the wooden and bone shafts of several other tools and weapons. It must be emphasised that even in this second stone age man was still a hunter. But the methods by which he hunted must have changed a great deal. Because his tools were small, he could carry them into the interior where raw material was not easily available. Thus a much larger area than before was penetrated by man. We may call this the advanced hunting and food-collecting stage. No remains of contemporary animals have been found. Presumably, the earlier species continued to live. Two carbon-14 dates from the Mula dam, Ahmednagar district, help in dating this cultural stage around 31,000 years before present.

Third stage

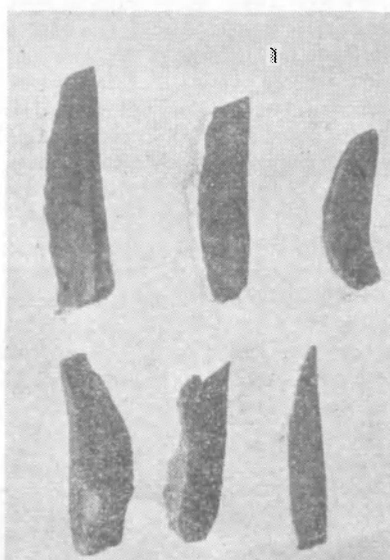
The next stage is fairly well-documented, as from excavations at Attirampakkam, from the Rallakalava, near Renigunta in district Chittoor and from several sites in Kurnool district. Instead of a large number of points and several kinds of scrapers, we get thin, long flakes called blades. Among these blades we notice tools which could have been used for no other purpose than for engraving on wood and bone. This is a definite advance on the previous two stages.

Unfortunately not much is known of this man. But further information may come to light if more systematic work is carried out. The most important sites from my point of view are the caves around Madras and in Kurnool district, where some 60 years ago, Robert Bruce Foote had found not only such fine tools, but even artistic work on bone which he then compared with similar work discovered at that time in the caves of France (called Upper Palaeolithic, it is now well dated, the various sub-periods covering a span of 10,000 years, i.e. 20,000–10,000 years before present). Unfortunately all the collections made by Foote have been lost.

Fourth stage

From this advanced stage man had changed again. His tools had become still smaller ; the tools and weapons are so small that we call them microliths. These are the precursors of the later tools and weapons of copper, bronze and iron ; for the first time man had discovered the principle of compound tool. He hafted the tools in a bone or a wood or even a clay handle as teeth.

Until very recently, microliths were found on the surface. But now at Sangankal, near Bellary, these have been found sandwiched between the layers containing tools of the late-Early Stone Age or Middle Stone Age and tools of the New Stone Age when man had definitely taken to agriculture and domestication



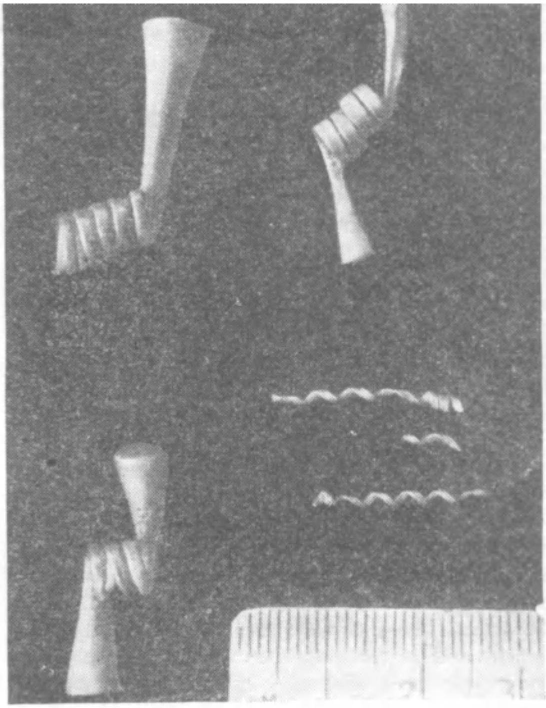
of animals. Thus this transitional stage, called Mesolithic, is extremely important and comparatively very well dated now. Some evidence is also found in the fossil sand dunes in the far south at Tirunelveli. We can date it provisionally to 4,000 B C or earlier, though in Western Asia, such a stage of development took place around 10,000 B C.

The small tools were used for various purposes : for hunting with bow and arrow, as harpoons for fishing, and also used as sickle-teeth for very primitive harvesting. Thus these small tools do indicate a very important step taken by man towards economic self-sufficiency. Unfortunately, except for some data from Ceylon on microliths in quartz and crystal — though not yet dated — the whole of South Asian prehistory remains a confused and virtually non-stratified world. However, a number of sites in the South-eastern parts of Australia have produced evidence of Pleistocene colonisation of the continent and at the Kenniff cave, quartz microliths have a Carbon-14 date of 1880 $\pm$ 190 B C. And a still earlier industry in quartz flakes have dates ranging from 10,660 to 14,180 B C. So it is possible to infer that man might have migrated to Australia from India in two or several waves under favourable conditions, such as low sea-level and with the help of dug-outs.

No human skeletal remains of this period have been found anywhere in South India. But those found from Langhnaj in Gujarat do show some features which remind us of the Veddas of Ceylon.

Fifth stage

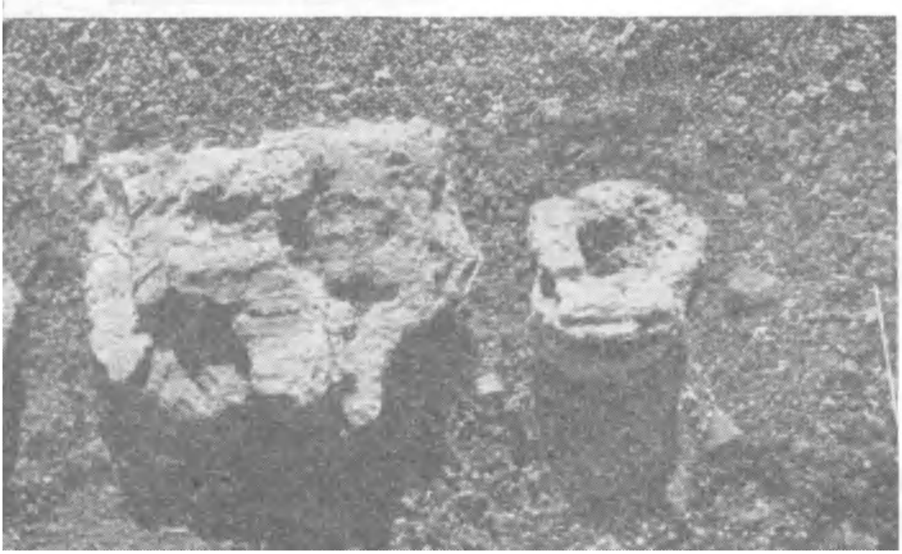
The first conscious steps towards agriculture were taken on the granite hills in South India. These hills look picturesque and foreboding, like castles

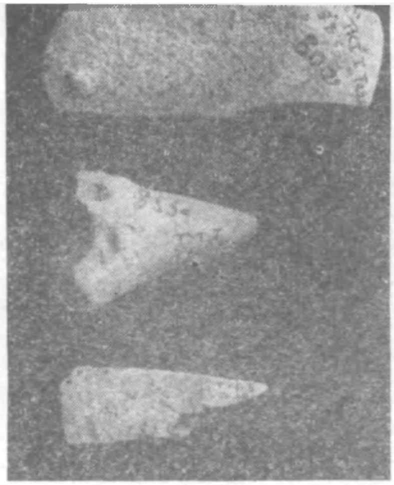


Three gold ornaments and three gold wires from Tekkalkota (c. 1,500 B C)

from a distance, and as one goes nearer, one sees huge boulders perched one on another as if placed by man and some about to fall down at any moment. But these have been there for the last 5000 years or more. If one takes the trouble of climbing these hills which are 100 to 200 metres high, one finds a beautiful enclosed area, fairly flat. These flat areas were inhabited by man around 2,000 B C. These were the earliest settlements of man.

Below, left (facing page) : Stage IV — microliths from the Rallakallava (c. 10,000 — 3,000 B.P.). Below (centre): Split bamboo impression on clay from a house at Tekkalkota (c. 1,500 B C). Below, right : Woven mat impression on an earthen pot from Tekkalkota (c. 1,500 B C).



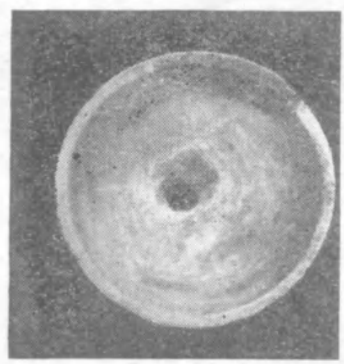


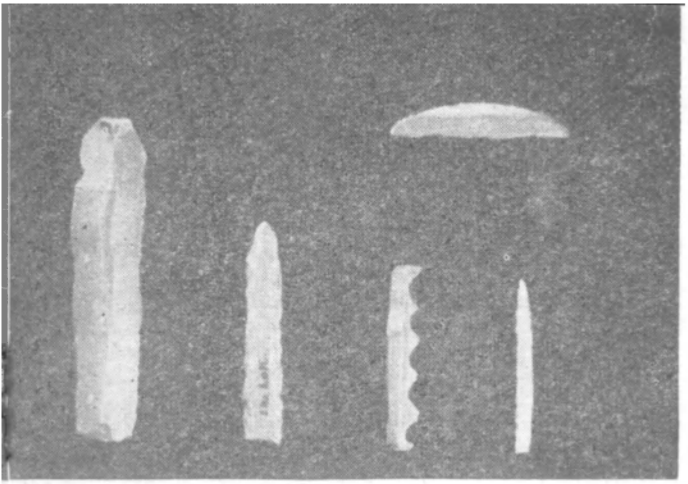
As soon as man took the first step of settling down, he was in need of houses and of utensils. We have some evidence from our excavations at Tekkalkota in district Bellary and at Hallur in district Dharwar that this man cultivated *hurali* (kan), *ulavalu* (tel), *kollu* (tam) or *kulthi* (hinid) and *ragi* (horse gram and finger millet) — two of the most staple items of food in South India. Both *ragi* and *kollu* flourish on sandy, lateritic, even hilly, areas. And it is perhaps not just a coincidence that the areas of the maximum concentration of the Neolithic and Megalithic sites overlap with those of *ragi* and *kollu*.

It is interesting to note that both these grains as well as green gram occur later at Paiyampalli, North Arcot district. (*IAR*, 1964, p. 38).

These people, besides making use of the natural rockshelters on these hills, also built " houses ", indeed small huts, which were usually round, supported by round wooden posts, about 5 to 8 cm in diameter. These huts were covered with split bamboo screen, and occasionally the walls were partly or wholly plastered with clay mixed with cow-dung. The roofs were presumably conical and invariably thatched. Some huts were about 5 metres in width. The floors were levelled by placing flat-topped stones and then bonded with clay and finally plastered with lime. The minimum " furniture " inside these huts consisted of a fire-place made of three stones or, as at Hallur, of a small pit sunk into the floor, and a

Below, left: Pottery including a " head-rest " from T. Narasipur, Mysore (c. 1,700 B C). Bottom, left: Spouted pot and deep-sided bowl from Piklihal, Raichur dist. (c. 2,000 — 1,500 B C). Below and bottom right: Four-footed bowl from Piklihal (c. 1,500 B C)





Above, left: Long and serrated blades (saws) and crescentic blades used by the neolithic people at Tekkalkota (c. 1,500 BC). Above : Bone tools from Tekkalkota (c. 1,500 BC)

storage jar which stood on three terracotta legs. In the empty space between the base of the storage jar and the floor were kept polished stone axes, and sling stones. At a rough estimate at least 5 to 6 people could live in these small round huts (as Boyas do today), and we find that in a terrace at Sangankal or at Tekkalkota, there would be at least 10 to 15 such round huts. From this we can deduce that a small community of 80 to 100 people lived on each terrace and a hill like Tekkalkota, where there are no less than 20 such terraces, could accommodate a population of about 2,000 people at the minimum. There are numerous such hills spread from Mahebubnagar in Andhra to North Arcot district or Salem in Madras through Anantpur and parts of Cuddapah.

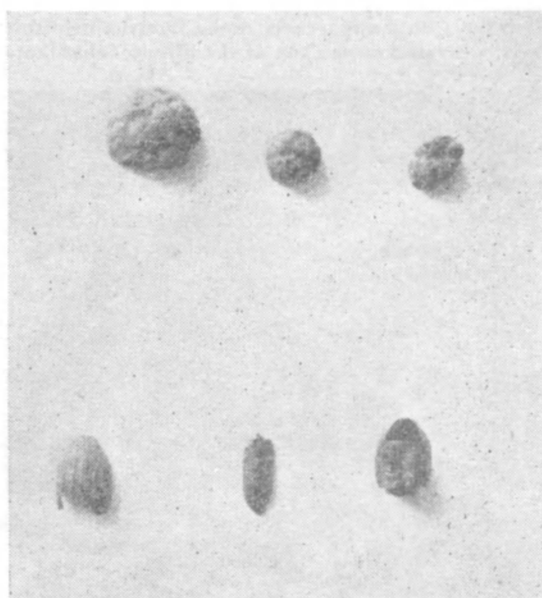
When we say that these people lived on these hills, it means that there was a society. Groups of people came together to build such houses and at Tekkalkota we had the definite evidence that they moved large stones and enclosed the periphery of the hills where there were no natural stones affording such privacy. And these stones were so heavy that they could be moved by not less than 5 to 10 people, on the principle of inclined plane. There were also paths made with stone, avenues and artificial irrigation systems for leading rain water from one terrace to another. These are signs of planning and organisation. Here, the first stage of man towards civilisation had been reached.

Other things are also suggestive. The pottery, for instance. It is not primitive ; on the contrary, it is highly sophisticated. There are vessels resembling our teapots. Other vessels look like ice-cream cups and wine-cups because they have permanent pedestal or foot and then there are vessels with 4 to 5 pinched openings. Huge storage jars were also found. When we look at their tools and weapons, we find that they are still of stone, but they are completely different ; the tools are now beautifully ground or polished. This itself means that man had to live at one place so that these beautiful tools could be made. It takes at least a week or a fortnight to grind these tools, and for grinding they had to have huge concave or boat-shaped grinding stones. These are found in these terraced hills in their natural state. In addition, knives, saws, arrow-heads and harpoons were made of thin blades of chert and chalcedony. Copper was known, but was rare, and used sparingly. While at Tekkalkota the usual flat copper axe was found, at Hallur were found two unique small double axes.

These people's sense of organisation as well as community life and their thought of the next life is again indicated by the way they disposed of the dead. We find that they buried their dead where they lived, in pits, in an extended posture. Slightly later, the body was kept in pots either horizontally or vertically and very often several smaller pots were placed inside. These are the precursors of coffins of the later period. From the evidence at Tekkalkota, and Brahmagiri and Piklihal, one might infer that bodies were possibly exposed and when they were sufficiently dried up, the bones were carefully picked up and rearranged as naturally as possible and kept in the pots called urns.

So far no excavation in South India (as defined earlier) has yielded any evidence to infer about the

Charred grains of *kulath* from Tekkalkota



religion of these people. From Nevasa in district Ahmednagar, come two terracotta female figurines, one of them the largest so far found in India. Both are standing, have prominent breasts, stumped, outstreched hands, and featureless heads. This mother-goddess was worshipped in Western Asia from a much earlier period. She was also probably worshipped in Maharashtra between 1,300 and 1,000 B C, but we cannot say whether she was worshipped further south too.

Perhaps the bull was held in high esteem to judge from paintings and engravings on rocks and terracotta figurines. Whatever it be, man at this period had formed some definite idea about the life after death. For he buried his dear ones ceremoniously within the habitation, first on bare ground in an extended manner with a few pots near his head, and then in pots placed vertically or horizontally, along with a few pots (and with ornaments as attested from Nevasa and Chandoli in Maharashtra). Chemical analysis has proved that a child's body at Nevasa was anointed with cow-dung and oil.

Charred grain from Tekkalkota, and charcoal from Utnoor, Sangankal, Tekkalkota, Paiyampalli and T. Narsipur, and Hallur enable us to say that this culture, called the Neolithic or Polished Stone Axe Culture, flourished from about 2,200 to about 900 B C. We may call it the earliest beginnings of civilisation. Right from the selection of the site (hills, with flat areas or areas intentionally made flat) to building round and/or square houses, often plastered with lime, furnishing them with highly utilitarian storage jars and sophisticated pottery, and making stone tools by grinding and chipping and burying the dead with pots and pans in the houses, shows a well-organised way of life, dependent partly on agriculture and partly on stock breeding and hunting. This man was also an artist. He has left numerous paintings and bruisings in the rock shelters. This is further documented by exquisite pin-hole decoration on pottery from Tekkalkota.

Another " first " these people had to their credit was the exploitation of gold in the Raichur Doab. The earliest gold ornaments in South India were made by them. They were also the first to use copper in South India.

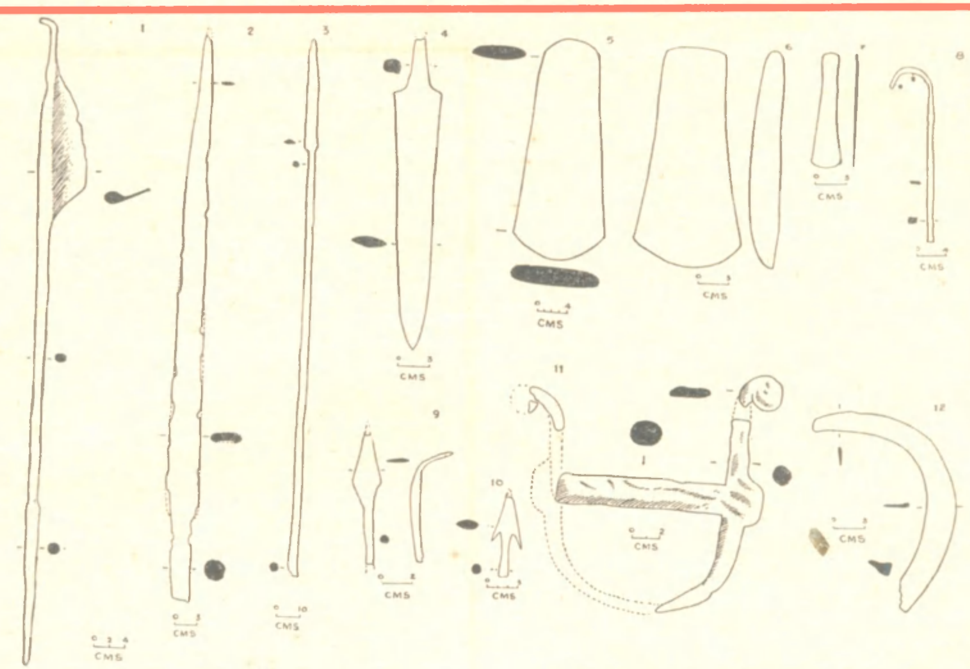
But we have no idea whether or not this man knew writing. Except for this fact, we can say that he was civilised and this civilised stage is found almost all over South India, except for the extreme south, viz. Tirunelveli district. The beginning possibly took place in Raichur and Bellary districts where

Dating the past

Carbon-14 (or C-14) dating is one of the few methods of dating objects found in any excavation objectively and absolutely. Discovered in 1947, it is based on the principle that vegetation absorbs carbon dioxide, which contains carbon-14 atoms, from the atmosphere. Cosmic rays bombard the upper atmosphere. This produces fast-moving neutrons. The latter colliding with atmospheric nitrogen atoms produce tiny amounts of carbon-14 and hydrogen. The former (carbon-14) combines with oxygen to become dioxide.

When animals feed on vegetation they add carbon-14 to their bodies. But when plants and animals die, carbon-14 disintegrates and reverts slowly to nitrogen. Professor Libby discovered the principle that all living organisms contain the same proportion of carbon-14, and, after death, organic materials lose their carbon-14 at the same rate. It is calculated that half disappears, in 5,568 years (or, according to a revised estimate in 5,730 years), a half-life. Three-fourth of C-14 dissipates in two half-lives, and so on. When, therefore, the radioactivity of modern carbon is compared with radioactivity in ancient carbon-charred grains, wood, bone, hair or shell, it tells us the amount of time that elapsed since the death or destruction of the sample under examination. This is usually determined in an atomic laboratory.

Two boya huts apparently made like the neolithic huts excavated on the top of the hill at Tekkalkota



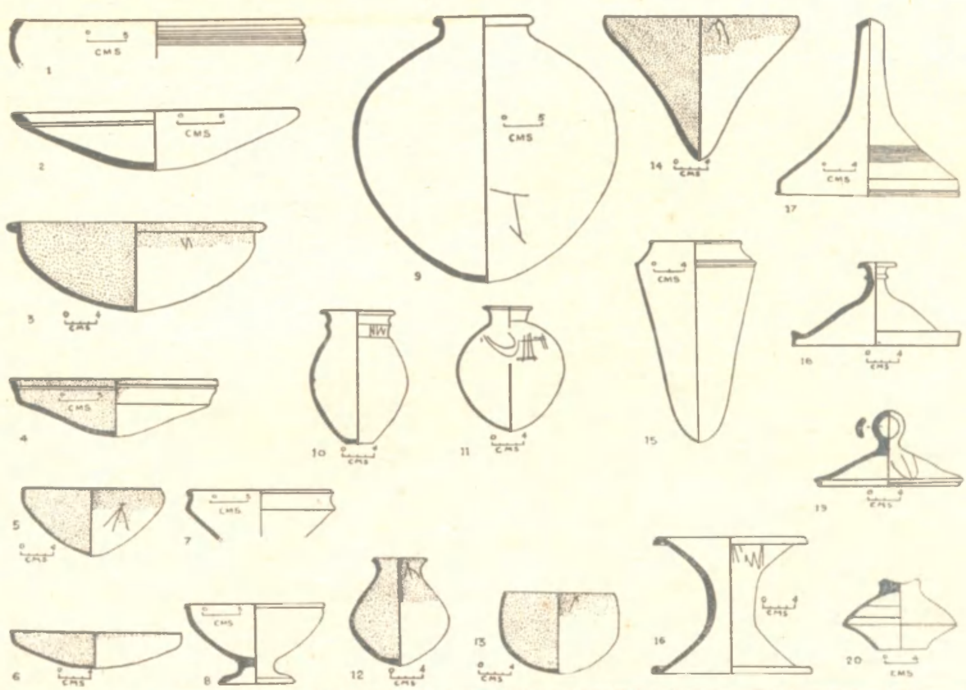
Above : Drawing of iron tools and weapons from the megaliths at Brahmagiri, Sanur and Amrithamangalam.

1 — Roman-type coulter ; 2-3 — spears; 4 — dagger; 5-7 — axe, wedge and chisel ; 8 — long hook; 9-10 — two types of arrowheads; 11 — horse bit; 12 — sickle

Below: Drawing of pottery from Iron Age megaliths.

1-8, 13 — bowls and dishes; 9-12 — storage vessels; 14, 15, 17 — typical funnel-shaped and tapering end vessels; 18, 19 — lids; 16 — pottery rest; 20 — peculiar vessel.

Note: (i) Drawings with fine black hatchings indicate vessels with fine black top and red bottom (ii) Some vessels, e.g., 5, 11 show graffilli (post-firing engravings on the surface)



there are very fine hills, and from this man later spread to the Kaveri delta on the east and the Mysore plains on the west.

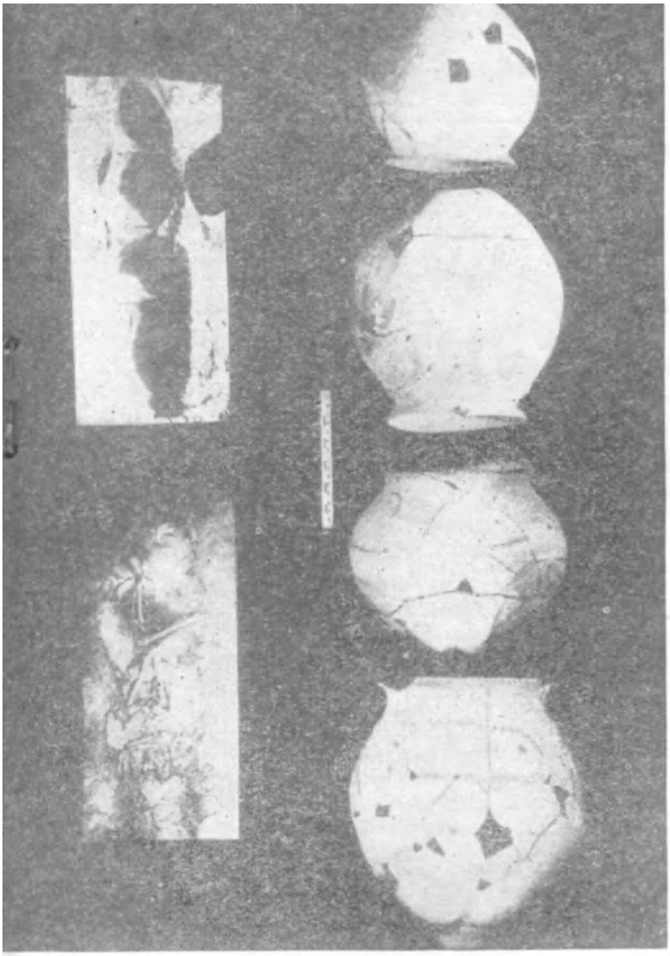
Where did this man come from ? There is no definite answer. Anthropologists who have studied the human skeletons from Brahmagiri, Piklihal, Takkalkota and T. Narsipur think that this man might be connected very distantly, partly with the aboriginal population of South India and partly with the people from distant Iran. Thus even at this early date of about 2,000 BC, we can say that the population of South India was not pure but quite mixed. And this is also indicated by the stone tools and above all by pottery. The pottery from Piklihal, Sangankal, Tekkalkota and T. Narsipur does suggest affinities with that of Iran and Western Asia.

Sixth stage

How and when this man changed, we do not know. But now, all over South India, we find that a great change had come over in their way of living. This was very well demonstrated at Brahmagiri where beautiful black-topped pottery with red bottom, and iron tools were found in association with stone tools and pot burials.

This is commonly called the Megalithic Period (or Culture) a time when man used underground or overground tombs made with large hewned or roughly hewned stone slabs. The very conception of burying the dead in such structures and the organisation behind it anticipates a well-knit social order. Formerly, after the excavations at Brahmagiri, it was supposed that this great Megalithic Culture which had spread all over South India, in practically all the districts of Andhra, Mysore and Madras, except perhaps the coastal districts on the east and the west, was not older than 250 BC. Mortimer Wheeler thought that these megalithic people, who possessed iron weapons — swords and spears — and other iron tools, must have ousted the Maurian emperor from the south. But this now seems to be a mistaken view. In fact, evidence is accumulating that these megalithic cultures are at least three to four centuries older. It also appears from our own survey, and excavations by A. Sundara of the Deccan College at Terdal in the Bijapur District, that some of the megaliths in the great sandstone area are older and belong to the Copper Age which ended in that region about 1,000 BC. (*IAR.*, 1965–66, I.P. 65). This is also suggested by Tekkalkota and further corroborated by Nagaraja Rao's excavations at Hallur in Dharwar district (*IAR.*, 1964–65, I). Here we have one of the earliest dates for the Megalithic in association with Chalcolithic Culture (c. 900 BC.) (*TF.* 750 and 573, *IAR.*, 1965–66, *vol. 6*). If this is accepted, then we can presume that a further step towards civilisation in South India was taken at about this time.

Careful excavation has revealed how much care, planning and organisation had gone into the construction of these huge monuments. Architect or artisan, potter or priest, whoever he was, must have joined in their preparation or completion. Hence the observation of the day of mourning as holiday. These people used iron tools and weapons and a beautiful pottery with black top and red bottom as well as several other vessels for storing, drinking, eating, and also burying the dead.



Almost everywhere, these megalithic structures are on barren rocky terrain, either granitic or lateritic. Surveys in Chingleput district have shown that these megalithic habitations lie near artificial ponds. It is also believed that these artificial ponds were first made by the megalithic people and here for the first time we find irrigation conducted with the help of these ponds. It is quite possible that these ponds which lie strewn over Andhra, Mysore and Madras, are the creations of the megalithic people.

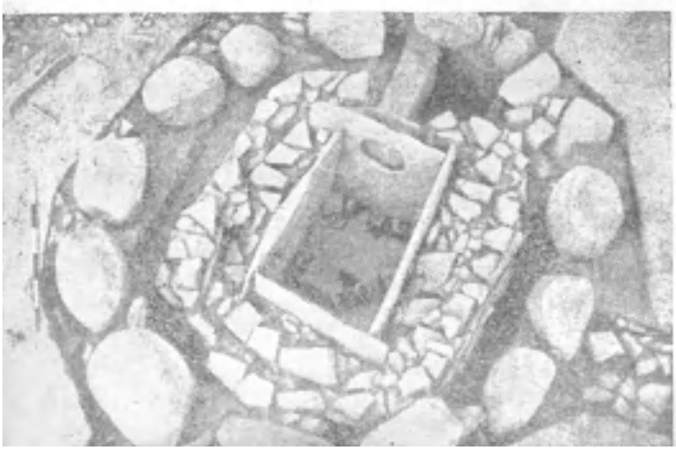
We have already found from our excavations at Tekkalkota and Hallur the earliest traces of *kulath* (*Dolichos biflorus*) and *ragi*, two of the staple items of diet in this region. But when did rice enter the diet ? We do not have actual proof, but, I think its first use should be credited to the megalithic builders, though it was known in Central India, Saurashtra and Bengal much earlier.

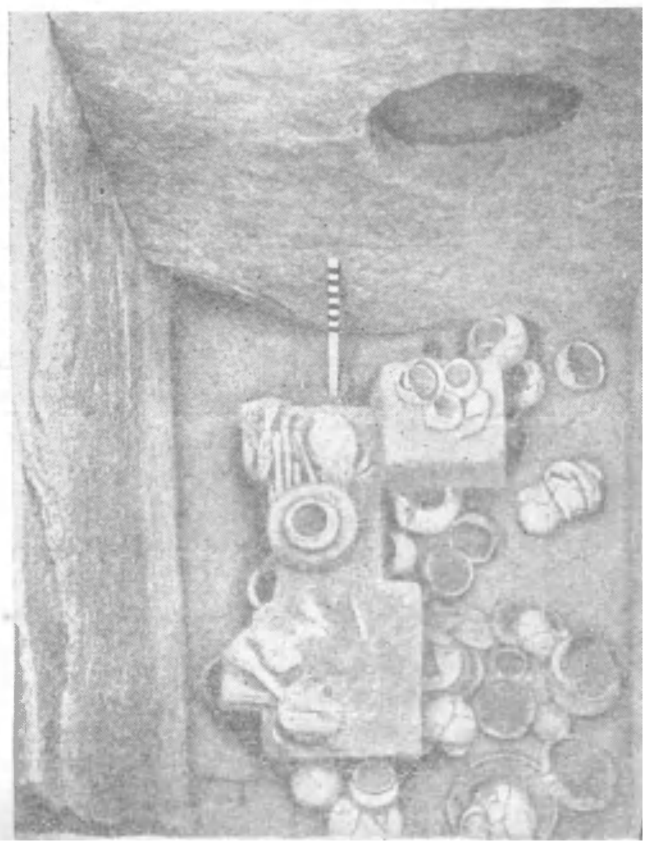
They must have planted rice and obtained at least two to three crops, as the people in South India do today, with their irrigation ponds and lakes. For ploughing in sticky, heavy soil, Roman-type coulter was used, as shown by the identification of an iron implement with long handle, sharp blade and hooked end from the Brahmagiri Megalith II. It is indeed a great pity that except for the several types of megalithic tombs, we do not know how they lived — their town and city life or even the village life.

Burial practices. Above: Three views of a four-pot burial (Tekkalkota, c. 1,500 B C)

Facing page: Excavated Megalith II showing contents of sarcophagi (terracotta coffins with several legs and covers) from Sanur in Chingleput dist. (before 250 B C)

Below: Excavated Megalith VI showing the method of construction. (Brahmagiri, c. 200 B C — 50 A D). Close-up view (below, right) shows contents of megalithic (underground) cist with a port-hole in the wall for inserting offerings and human skeletal remains





THE BEGINNING OF CIVILISATION

(2,00,000—2,200 years before present)

Stage	*Typical important sites*	*Man and artifacts*	*Habitation*
I 2,00,000 years before present	Vadamadurai (D. Chingleput)	Heavy, crude stone tools (handaxes, choppers)	River banks and foot-hills
IA 50,000–75,000 years before present	(*i*) Attirampakkam (D. Chingleput) (*ii*) Giddalur (D. Kurnool) (*iii*) Anagwadi (D. Bijapur)	Comparatively light, symmetrical stone tools (handaxes, cleavers)	River banks and foot-hills
II 20,000–40,000 years before present	(*i*) Attirampakkam (*ii*) Giddalur (*iii*) Anagwadi	Comparatively light small stone tools, points, awls, scrapers	River banks, foothills and light forested regions away from rivers
III 30,000–20,000 years before present	Vadullacheruvu near Renigunta (D. Chittoor)	Thin, long, flat, small blades of stone, knife blade, burins (chisels), points	River banks, foothills, rock-shelters, caves
IV 10,000–4,000 years before present	(*i*) Teris of Tirunelveli District (*ii*) Sangankal (D. Bellary)	Very small tools of stone (microliths), blades, points, scrapers, burins	River banks, foothills, rock-shelters, caves
V 4,000–2,800 years before present	(*i*) Paiyampalli (D. North Arcot) (*ii*) T. Narsipur (D. Mysore) (*iii*) Palavoy (D. Anantapur) (*iiiA*) Brahmagiri (D. Chitaldrug) (*iv*) Sangankal (D. Bellary) (*v*) Tekkalkota (D. Bellary) (*vi*) Piklihal & Maski (D. Raichur) (*vii*) Utnoor (D. Mehbubnagar) (*viii*) Hallur (D. Dharwar)	Skeletal remains with mixed features. Partly indigenous and partly Western Asiatic; polished stone tools (axes, chisels, adze); thin blade tools; flat copper axes, pins	First settled villages on river banks, foothills and castellated hills with rock-shelters
VI 2,800–2,200 years before present	(*i*) Adichanallur (*iA*) Sanur (D. Chingleput) (*ii*) Amrithamangalam (*iii*) Paiyampalli (*iv*) Brahmagiri (*v*) Sangankal (*vi*) Tekkalkota (*vii*) Piklihal (*viii*) Terdal (D. Bijapur)	Skeletal remains, mainly skulls, from Adichanallur, Brahmagiri. Proto-Australoid & Mediterranean like the Veddas of Ceylon. Fine wheelmade pottery; iron tools and weapons; ornaments of gold, copper and semi-precious stones; construction of underground and overground huge stone burials	First cities (?) — Isila-Pattana, Kaveri-Pattana, and villages on river banks, foothills, castellated hills, with rock-shelters. Historical Kingdoms of Cholas, Cheras and Pandyas

IN SOUTH INDIA

Man's activities

Food-gathering by hunting, fishing, snaring and collecting wild fruits and roots

Food-gathering by hunting, fishing, snaring and collecting wild fruits and roots

Food-collecting by hunting and fishing (*but now with spear and lance also*) and collecting roots and fruits

Intensive food collecting in specified areas with finer tools and weapons (stone prototypes of our steel knives and chisels for cutting, slicing and engraving)

Intensive fruit collection as in III, but now with compound tools and harvesting or cutting naturally growing grass

(*i*) First traces of built houses — round, square, lime floor, with storage jars and stone fire-place or sunk-in *chulahs*
(*ii*) Burial in pits within habitation with or without pots
(*iii*) Pottery making
(*iv*) Arts and crafts — painting, bruising on rocks, ornaments
(*v*) Copper-smelting (?)
(*vi*) Ornaments of gold, faience, steatite and semi-precious stones
(*vii*) Trade in rare stones and copper ingots and/or tools
(*viii*) Pastoralism and domestication of animals
(*ix*) Agriculture with stone hoe

(*i*) Construction of towns and cities and several types of underground and overground burials
(*ii*) Agriculture with irrigation — artificial ponds
(*iii*) Iron-smelting on a large scale all over South India
(*iv*) Arts and crafts
(*v*) Trade and commerce
(*vi*) First traces of earliest Tamil in Brahmi-like script (c. 100 B C)
(*vii*) Earliest Tamil literature

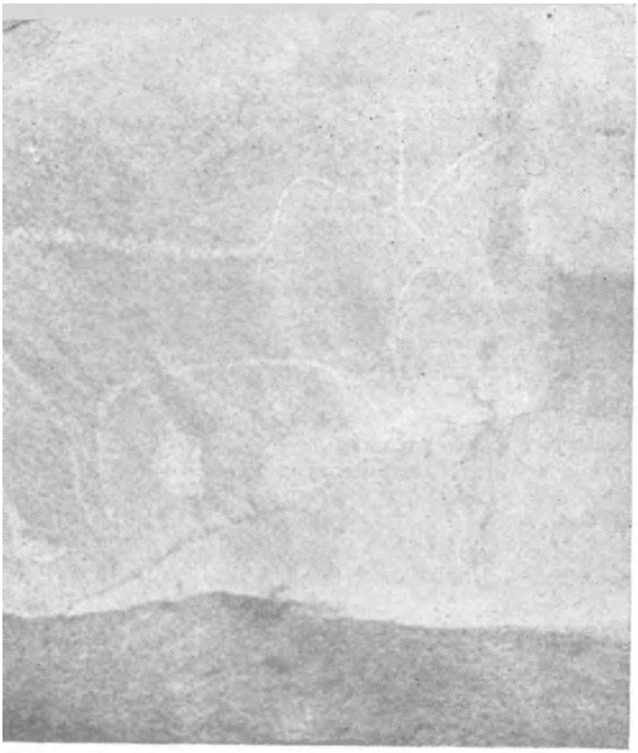
Of course there are traces of a city — a well-paved road has been found on the foot of the Brahmagiri hill. This has been identified with the ancient city of Isila. That these megalithic people were well-organised and also rich and prosperous can be easily seen from the funerary goods which, besides containing iron tools and weapons and very fine pottery, also contain numerous gold beads and beads of semi-precious stones, and shell. And it is this life which is depicted in the early Tamil literature. Recently new evidence has come out from excavations at Palavoy, district Anantapur, which indicates that the ashmounds, which are almost invariably associated with neolithic and megalithic sites, were not simple heaps of cow-dung burnt ceremoniously on occasions, but were in fact ovens for smelting iron. If this is established, we can further credit these people with large-scale iron smelting in South India.

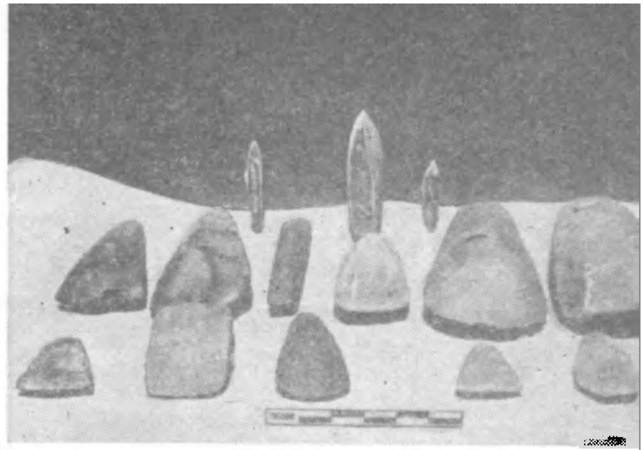
Literacy in the South

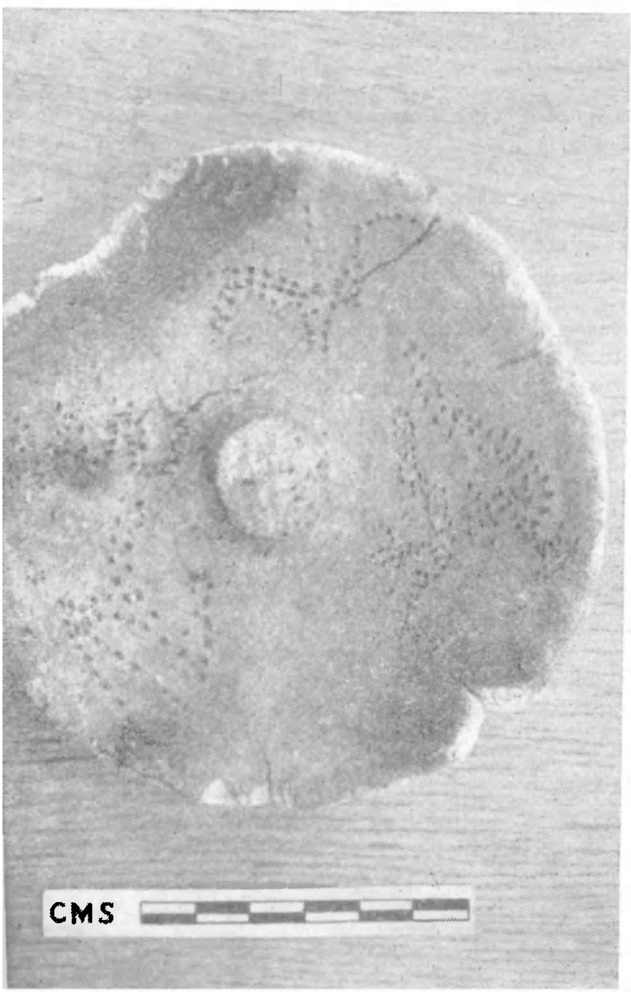
One question remains. Did these people know writing ? Here, unfortunately, the evidence is very meagre or almost nil. It has been supposed by Furer Haimandorf that since the area of the megalithic culture overlapped with that of the distribution of the present Dravidian languages, Dravidian was introduced by the megalithic people. And, independently of Professor Haimandorf, I have come to the conclusion (when I saw the Asokan edicts at Maski, Brahmagiri and Kopbal) that these edicts could have been addressed only to people who could read and write — i.e. the megalith builders — and not to their predecessors, the neolithic pastoralists. Further, the evidence from Arikamedu, Pondicherry shows that the early Dravidian script was allied to Brahmi, and more than 2,000 years ago the Tamilians could read what was written by the northerners, and the northerners could read what their brethern wrote in the south. That this was the case is quite probable though, as pointed out by the late Professor Gordon Childe, we do not have the proof for the migration of the Dravidian from Finno-Ugrian to South India as we have for the Aryan languages. Consequently, according to the present data, the South Indian megaliths, though in one essential feature identical with the Western European, viz. both possess the port-hole cist, had been separated spatially as well as in time. The European megaliths are at least from 2,000 B C, whereas, even according to our new dating, we cannot place the South Indian megaliths before 700 or 900 B C.

New evidences

Here, however, we can refer to some new evidences that have come up from the discovery of stone cists







Above: Polished stone axes, adze, chisels and a copper flax axe (second from left, bottom row) from Tekkalkota (c. 1,500 BC)

Left, above: Engraving of a large bull on a rock at Tekkalkota. Left, below: Pottery lid with punctured decoration showing a bull with wavy horn (top, centre), serpent and a deer with long horns (left, centre and below) and a peacock (right) (Tekkalkota, c. 1,500 BC)

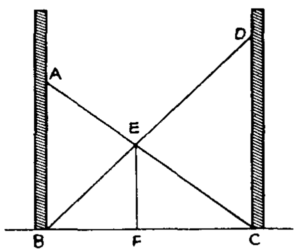
by Dr. Fairservis in Eastern Las Bela in Baluchistan, West Pakistan. These cists are generally oriented east-west, and are made of upright slabs standing up to a metre in height. There is a tendency for these cists to be clustered in groups on tops of ridges. Occasionally the cists have a capstone and in one case, Sherman Minton found a port-hole in one of the upright slabs. It is unfortunate that none of these Sind-Baluchistan megaliths have been excavated. But we have evidence now, according to Fairservis, which reaffirms a rather extensive megalithic complex in the eastern portion of the Indo-Iranian border lands. Thus it is possible that the great megalithic builders of South India were partly indigenous and partly western-oriented ; a study of the skulls showed a mixture of the Mediterranean and Proto-Austroloid traits, like the Veddid types. This is said to be a feature of the present day Dravidian-speakers.

Our survey of the existing evidence shows that until about 4,000 years ago, the cultural development in South India did not materially differ from that of the rest of India. Then just as a unique civilisation grew up in the Indus Valley, taking advantage of the natural factors, in the same way South India chalked out its own lines of development, according to its peculiar environment, viz. castellated hills, looking down red, rocky plains, occasionally interspersed with stretches of rich fertile soil. Nature and man thus effectively combined to give the earliest South Indian cultures their individuality.

FUN WITH FIGURES

A PYTHAGORIAN PROBLEM

HERE is one more puzzle from geometry. AC and BD are the two ladders placed between two vertical walls AB and CD. From the crossing E of the ladders, a perpendicular EF is drawn to base BC.



Under the above mentioned condition, all the dimensions AB, EF, DC, BC, BD and AC are full integers. Can you find the value of EF, when

(i) Both the ladders are of equal length and this length is the minimum possible.

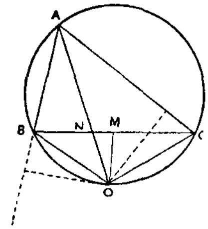
(ii) When the ladders are of unequal length and the length of the longer ladder is a minimum.

(Hint: The figure involves right angled triangles for which the integral solution is given by $x^2 + y^2$; $2xy$; $x^2 - y^2$)

●●

FALLACY OF A TRIANGLE

COULD you spot the fallacy given in our last issue? The fallacy lies in the diagram. When the sides AB and AC are unequal, the angle bisector of A and perpendicular bisector of BC meet outside the triangle in such a way that the crossing point lies on the circumscribed circle, and the perpendiculars drawn from this point on the smaller side AB lies outside AB, whereas the perpendicular on the larger side AC lies inside AC only.



Proof: Draw the circumscribed circle of triangle ABC. Let the perpendicular bisector of BC meet the arc BC at O. Join AO crossing BC at N. Join BO and OC.

As MO is perpendicular bisector of chord BC
Arc BO = Arc CO

Hence the angles subtended by these arcs BAO and CAO are equal. Hence AO is the bisector of angle A. Again, when AB and AC are unequal, assuming $AC > AB$

We have $\angle B > \angle C$

Now $\angle ANB = \frac{\angle A}{2} + \angle C$ and $\angle ANC = \frac{\angle A}{2} + \angle B$

As the sum of these two angles is 180°, $\angle ANC$ is greater than 90° and AN and OM cannot meet above BC.

Again using the properties of a circle,

$\angle OBC = \angle OCB = \frac{\angle A}{2}$ (angles subtended by equal arcs)

Hence $\angle ACO = \angle C + \frac{\angle A}{2}$ and

$\angle ABO = \angle B + \frac{\angle A}{2}$

Thus $\angle ACO$ is less than 90°, and $\angle ABO$ is greater than 90°. Hence, the perpendicular from O on AC is inside, and on AB, outside.

B. S. Chopde

MAN THE CREATOR

BRUCE FRISCH

TO learn to control life, we must create it, says the Russian scientist Alexandr Oparin. We are progressing so quickly toward this goal these days that it is hard for science prophets to keep up their status as visionaries.

By far the most ambitious scientists are those who are trying to duplicate the original living cell the way nature made it. They don't even know what the cell they are trying to make was like. And experts have agreed that a fossil of it couldn't exist. Fortunately, a few people stubbornly went with the search and have made spectacular progress.

Should these men reenact the origin of life, they will make man a creator in truth.

From the original recipe

The whir of an atom smasher in 1951 stirred in scientists the dream of building life out of raw chemicals just the way nature had done. Dr. Melvin Calvin bombarded carbon dioxide dissolved in water with the high energy radiation from the 153 cm cyclotron at the Berkeley campus of the University of California. What emerged were organic chemicals, demonstrating how the first steps toward life may have begun on primitive Earth. Of course theorising on "creation" had started long before. British scientist J. B. S. Haldane had written a book on the subject in 1932, and so had the Russian Alexandr Oparin, in 1934. But

it was Calvin who set off a flurry of actual experimentation.

Another boost came in 1957 when launching of *Sputnik* touched off a rocket race between the United States and the Soviet Union. With the possibility of reaching another planet imminent, scientists found themselves unprepared. How would they detect primitive life on another planet? How had it started and what forms had it taken on Earth? They didn't know. So a new wave of experimentation was launched.

Today, Dr. Sidney Fox, Head of the Institute of Molecular Evolution, University of Miami, proposes a complete outline of the origin of life. In simple how-to-do-it steps, the "act of creation" as seen by Fox and Oparin goes like this: 1. From the gases in the primitive atmosphere make the simplest chemical building blocks of life. 2. String together or polymerise the simple chemicals into huge macromolecules similar to protein. 3. Package the protein-like material into concentrated packets, walled off from the world but trading freely with it — like a living cell, yet lacking life. 4. Select by competition from among the packets to evolve one bent only on growth and multiplication — in short, touched with life.

The natural process began with the formation of the Earth four to five billion years ago, out of dust and debris. None of the chunks was big enough, as scientists have pointed out, to bring with it an atmosphere. Earth was airless and cold. The internal radioactivity heated it up and started volcanoes spouting lava and gas.

Most scientists agree with Oparin, who believes the carbon now tied up in coal beds, coral reefs, chalk cliffs, oil and living matter was then in the form of methane, our swamp and sewer gas. Nitrogen, which today makes up 80 per cent of the atmosphere, he thinks, was combined with hydrogen as ammonia. Water vapour made up the balance.

There was almost no oxygen. Photosynthetic life has made the oxygen we breathe. Without oxygen there was little ozone (O_3) that today screens out ultraviolet radiation 35 km over our heads. We use ultraviolet lamps to sterilise things. Primitive Earth was bathed all day by its rays.

The conditions on primitive Earth would kill us, but they were right for the origin of life. Our present atmosphere would not allow life to be born, Louis Pasteur proved a century ago. The amino acids from which life is built would be destroyed by oxygen unless sheltered from it within the cell.

Earth was parched, too, having only about one-tenth the present amount of water, estimates Dr. Harold Urey, Nobel Prize winner from the University of California. Volcanic steam slowly filled the oceans. At the University of Chicago, Dr. Stanley Miller, a student of Dr. Urey, carried out certain experiments. Inside a glass bottle, he sealed a colourless mixture of methane, ammonia, water vapour and hydrogen, simulating the primitive atmosphere, through which he discharged sparks, simulating lightning. Reactions formed several organic chemicals, including amino acids, the building blocks of protein.

Since then other scientists have demonstrated several other presumably natural ways to form amino acids, as well as the building blocks for carbohydrates and nucleic acids and ATP, the molecule that powers the cell. Some researchers use ultraviolet as an energy source instead of electricity. So ultraviolet, which can kill life, may have been necessary for its formation.

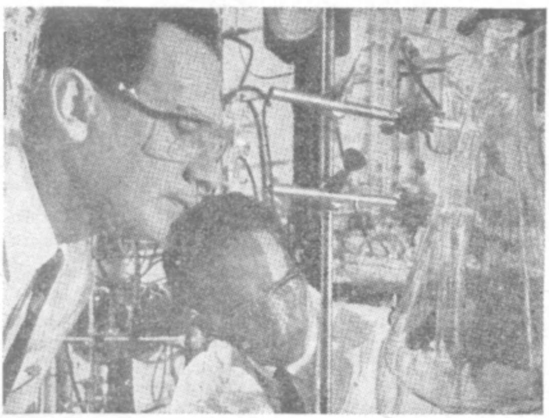
The next step is to join the small molecules into the large, complex proteins, carbohydrates and nucleic acids. For years the theory was popular that the small molecules washed into the ocean to form a thin soup. Given enough time, the right accidents would happen to join them up in the right order. Presto, there would be a molecule of DNA.

Oparin wryly notes: "Physicists assert that, in principle, it is possible that, by chance, the table on which I am writing may rise up of its own accord into the air owing to the simultaneous orientation of the thermal movement of all the molecules in the same direction." But he wouldn't base his scientific work on that possibility. It is also turning out that nature had less time than was thought, as older and older remains of primitive life are found.

Scientists began suggesting ways the reactions might have been speeded up. Dr. Clifford

Mathews sparked methane and ammonia, hooking together hydrogen, carbon and nitrogen into hydrogen cyanide. The hydrogen cyanide, in turn, reacted with ammonia. Before the products of a lightning bolt hit the ocean, he thinks, some were already protein. They accumulated on the surface, not as a thin soup, but as a concentrated scum.

The stage was set for step three, the gathering of protein into cell-like packets. Dr. Fox has a forceful demonstration of this. He spreads a powder of amino acids over a chunk of volcanic rock and puts it in an oven at cake-baking temperature for several hours. When the rock comes out, the amino acids have polymerised



Dr. Clifford Mathews (left) tests his theory of steps to protein formation

into protein-like substances he calls proteinoids. Over the top of the proteinoids on the rock he pours water and allows it to cool. Through the microscope the proteinoids are seen to have been formed into gloubules, what Dr. Fox has named microspheres. They are the same size and shape as oocoid bacteria, which some regard as the most primitive bacteria.

According to Dr. Fox, microspheres absorb chemicals (" food ") from the surroundings. They can sprout, and sprouts knocked off will grow into full-size microspheres — a sort of reproduction. If the acidity of their pool is raised, they divide — also reproduction. Dr. Fox has introduced zinc into microspheres to mimic metal-carrying enzymes that split ATP and tap its energy. Although he found the reaction much weaker than in nature, considerable activity was there.

Thus three of the four steps in originating life have been completed in the lab. Scientists are now working on the fourth and toughest — organising a microsphere into a cell. We should not be impatient. They have been working 17 years; it may have taken nature two billion.

The search for the original cell

Scientists who were trying to duplicate the original living cell in the lab had no model to copy. The old well-studied fossil dated from Cambrian times 600 million years ago was much too recent. That the trail of life had been lost at this time was partly because it marked a time of transition from single to multicelled life, and single-celled life was smaller and more fragile. The record of the times after this is clearly traced out by fossils buried in sediments which later hardened into rock. Heat and pressure have metamorphised most older sedimentary rock into other kinds, destroying all fossils in the process.

But in the sedimentary rocks that remained there were fossils. Scientists just hadn't been looking closely enough. Through the electron microscope, one billion-year-old rocks from the Bitter Springs Formation of central Australia and Michigan and Montana in America were seen to imprison several kinds of single-celled organisms. Among these fossils, animals, in the form of protozoans, make their last appearance as we work backward in time. Also present were fossils indistinguishable from some present-day types of algae. Over the last billion years, they may have remained unchanged by evolution.

Fossils almost twice as old were found in the 1.9 billion-year-old Gunflint Iron Formation along the northern shore of Lake Superior. The rocks were dense with life. It appears to be mostly photosynthetic algae which grew in sheets or mats in shallow water, but there were also bacteria and other organisms.

One fossil organism found near Kakabeka Falls in Ontario was shaped like an umbrella with a straight, bulbous handle; so it was named *Kakabekia umbellata*. When Dr. Sanford Siegel read about Kakabekia in the winter of 1965, it sounded like a living microorganism he

had found in soil at Harlech Castle in Wales the previous summer. Dr. Siegel pulled out his old sample for re-examination. In his lab, he tried growing his microorganism in three different atmospheres. In air it didn't grow at all. In methane and ammonia it grew modestly well. In a mixture of air and ammonia it grew best. "The Kakabekia-like forms appear to be a relic of the Precambrian," he concluded.

In 1966, E. Barghoorn and J. W. Schopf announced they had found fossil life in rocks 3.1 billion years old from South Africa. Under the electron microscope they sighted organised layers of spheres that looked like algae, rods they named *Eobacterium isolatum*, and filaments.

What was the original cell like? The consensus of scientific opinion is that it was a good deal simpler than even these bacteria and algae. Immersed in geologically formed proteins and other organic compounds, "the first living, simple form found itself in a mass of spare parts," speculates Dr. Henry Isenberg, microbiologist at the New York Downstate Medical Center. It probably used them directly. Some algae can switch from photosynthesis to this mode of existence even today.

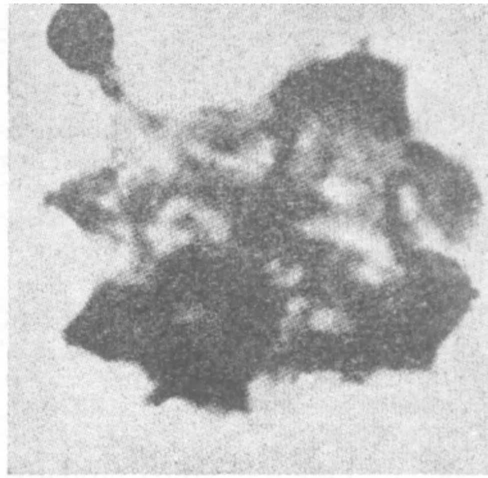
Immediately, with its birth, life destroyed the conditions necessary for its emergence, observes Oparin. It stripped the oceans bare of free parts and excreted contamination. As compounds disappeared, says Isenberg, probably only those cells survived that could make their own parts from simpler materials.

This original cell may be found yet. "It's a good bet" says Schopf, "we'll come up with some older."

Of mice and men

In Greek mythology there was a fire-breathing monster with a lion's head, a goat's body and a serpent's tail called a chimera. Chimera also means an impossible or foolish fancy. Today something very like a chimera is no longer so impossible (although opinion is divided on whether it is foolish).

The possibility was first sprung in 1965 when Prof. Henry Harris of Oxford University reported he had crossed a man and mouse. The actual partners were mouse cancer cells and cells called HeLa cells from a human cancer.



Fossil Kakabekia-form found in 2 billion-year-old rock (top) resembles organism (above) dug up at Harlech Castle in Wales

Harris mixed mouse and human cells with Sendai virus placed for three minutes under an ultraviolet lamp. All that remained of the virus's ability to penetrate the cell was the capacity to make the membranes sticky. As many as 20 cells in a clump stuck to each other and their cytoplasm blended. In some of these fused cells the nuclei combined into one. Hybrids survived up to 15 days, but no cell could be proven to have divided.

For almost a century, Harris explained, it had been known that some diseases, particularly virus diseases, caused cells to fuse in the body. Later it was learned that occasionally cells in culture fused spontaneously, probably, Harris guessed, because of an undetected virus.

A three-man team headed by G. S. Barski at the University of Paris began exploiting the spontaneous hybrids to make genetic studies. In 1960 they became the first to announce the combining of cells from different animals, two breeds of mice.

Boris Ephrussi who had watched their work at the University of Paris, now started his own experiments at the Western Reserve University in Cleveland with zoologist Mary Weiss.

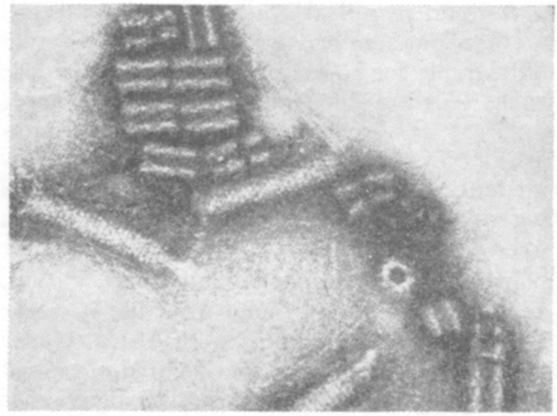
Ephrussi started out making only mouse-mouse hybrids. In some cases he joined normal cells to tumour cells. There had been an hypothesis that the wild growth of cancer was caused by the lack of a control gene. If this were so, the normal cell should have provided the hybrid with a control gene that would have made it grow normally. Instead, the hybrid was cancerous.

Ephrussi and Weiss went on to try crossing cells from different species, mouse and rat. " To our surprise, they were perfectly viable," says Dr. Weiss. Back in Paris, Barski's group was joining mouse and hamster as well as mouse and rat. Harris has created human-rabbit, human-rat and human-chicken crosses. But Ephrussi and Weiss were one step ahead. Their mouse-rat hybrid was the first interspecies cross to multiply.

After this the team broke up. Dr. Weiss went to New York University to work with Dr. Howard Green. Dr. Ephrussi returned to Paris.

Using the same techniques successful in Cleveland, Weiss and Green attempted a human-mouse hybrid. Since spontaneous cell fusions are rare compared to the wholesale fusing caused by Sendai virus, they had to use a special method to find and separate them. They deliberately chose mouse connective tissue that lacked the enzyme needed to take a vital substance called thymidine directly from the liquid medium in which it was cultured. The mouse cells had to make their own thymidine.

After mouse cells and human embryo lung tissue had been mixed and a few spontaneous fusions had presumably taken place, aminopterin was added. This killed all the mouse cells by preventing them from making thymidine. Human and human-mouse cells survived, although there were so few hybrids that none could be seen as distinct colonies which could be picked out and cultured separately. Up to 120 generations were counted, record longevity for a human hybrid line. " They could live indefinitely," says Dr. Green.



The T4 virus has over 100 genes, and all the parts had to be made separately

With their hardiness proved, could cell hybrids be used in another line of research being pursued by Dr. Beatrice Mintz at the Institute for Cancer Research in Philadelphia?

Dr. Mintz had taken the developing eggs from one black mouse and one white mouse at an early stage when they were made up of small number of cells. After removing the surrounding membranes she placed them together, and they adhered. Within roughly a day, the cells became thoroughly mixed, but each remained all black or all white. This composite egg was put inside a third, " incubator " mother. Growth, birth and rearing continued in a perfectly normal way. The mouse born had four parents plus a mother who was no relation. Since 1965, over 500 allophenic mice have been born and have begotten over 25,000 offspring.

The virus-makers

Even the first, simplest cell nature created was immensely more complicated than the virus. Thus many scientists felt the quickest way to create synthetic life was to learn to

create a virus. After the swarm of advances toward this goal in 1967, it looks as if they may have been right.

A two-pronged attack on the problem is being made. First, learning how to put together the parts of a virus. Second, learning how to put together the RNA or DNA that makes the parts.

In 1955, the assembly of virus particles that normally takes place inside a cell was performed in a test tube for the first time by Prof. Heinz Fraenkel-conrat, a bio-chemist at the University of California. He separated RNA from jackets and put them back together again.

Twelve years passed, during which no other virus was reconstituted. Then in 1967, the trick was turned four times. At Purdue University, experimenters disassembled, then reconstituted the RNA and spherical sheath of the cowpea chlorotic mottle virus. Later in the year, two graduate students at Harvard put together the three-piece bacterial viruses R17 and MS28.

The biggest leap was made by geneticist Robert Edgar and biochemist William Wood, who constructed the much more complex T4 bacterial virus. Instead of the five or six genes of the tobacco mosaic virus, T4 has over 100 genes. Instead of two parts, it has at least six. As a result, Dr. Wood and Dr. Edgar could not break apart viruses and put the same pieces back together. They had to make all the parts separately.

Synthesis of RNA and DNA that direct this whole operation began in 1955. Dr. Severo Ochoa at New York University combined the four chemical building blocks of which RNA is made, the enzyme that links them together, and RNA as a template for the enzyme to use in determining their order. He got out fresh RNA.

And in 1957, Arthur Kornberg, while head of the department of Microbiology at Washington University in St. Louis, did for DNA what Ochoa had done for RNA. For this work they shared a Nobel prize in 1959.

The genetic material they made looked and tested like the real thing except in one way — it didn't work; it did not direct the making of protein. Apparently the enzyme they extracted from cell sap was contaminated with just enough of other enzymes that attack RNA and DNA to render them impotent.

The purification problem was licked in 1965 by Dr. Sol Speigelman of the University of Illinois.

Greater acclaim awaited the man who could make synthetic DNA, because it is the carrier of genetic information in higher animals.

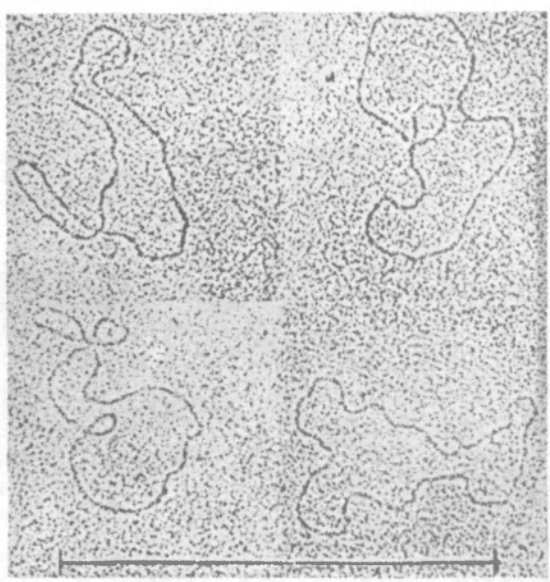
Prof. Kornberg, now at Stanford University, alertly coupled some recent discoveries with his own experience to claim the prize last December. The enzyme that the intestinal bacteria *Eschericia coli* uses to make its own DNA will also make the DNA of the *phi X 174* virus that infects it. The resulting DNA is linear, however, and *phi X 174* DNA must be in a circular form to be infective.

Early last year a second *E. coli* enzyme was found for joining the ends of the DNA strands. Kornberg used it to make DNA that *E. coli* turned into complete, infectious phi X174 virus.

" Before too long," says Kornberg, " I believe that it will be possible to circumvent the need for an intact cell."

After the virus should come the cell. These may not be the ways nature made her first cell, but they are probably the ways man will make his.

The synthetic DNA Professor Kornberg created



ARE YOU MAKING PROGRESS?

ANSWERS

See p. 27

Simple:

1. (a) 56 (The two numbers outside the brackets are added together, then doubled.)

   (*b*) 484 (The difference between the numbers outside the brackets is squared).

(5 points each)

Hard:

1. (*a*) Riverside (*b*) Cellar, Attic, Devonshire (*c*) Musicroom (*d*) 3.
2. Six and two-thirds days.

(5 points each)

Difficult:

1. BAKER (1) PILGRIM (4) (The figures are derived from the vowels in the names, taking the code A = 0, E = 1, I = 2, O = 3, U = 4).
2. MARY HAD A LITTLE LAMB (There is an alphabet code in which each letter is represented by a number equal to three times its place in the alphabet. Thus 39/3/54/78 becomes MARY).

(5 points each)

VERDICT

If you got **25 or 30 points:** You certainly have been making progress. This mark puts you in the highest intelligent class. You managed to get at least one of the questions in the " difficult " section and all the others.

15 or 20: You have above average intelligence, because you have managed to deal with the " hard " section. Keep trying . . . you may progress to the highly intelligent class.

10 or under: You have about average intelligence . . . but keep trying . . . you may gain promotion to the next sections.

SCIENCE: THE GREATEST DETECTIVE

Once upon a time, the greatest figures in the police organisations were the detectives. But in the last generation or so they have been beaten into second place by an even greater detective—SCIENCE. It is not a Maigret or any other human that killers fear now . . . it is the exact eye of the microscope

HENRY FULLER

THE murderer of a bygone age could feel safe if he left no fingerprints and nothing visible to connect him with his victim. But now killers are brought to justice by evidence unseen — a minute speck of dust, a millimetre of cloth, a thin strand of hair—things invisible to the naked eye.

It was science that took Harry Dobkin on a trip to the gallows. There is little doubt that if he had committed his murder 30 years ago, he would still be at large, for detectives used only their eyes in those days, and forensic science was still only in its infancy.

The story begins in April 1941. Londoners were facing the blitz. Almost every night the German planes came to drop their load of death. And amidst all this a man had time to think of murder.

On that April day Rachel Dobkin tried her best to make herself look pretty. For she was going to meet her husband, Harry Dobkin, from whom she had been separated for 20 years.

Their marriage had never been a happy one. Rachel had borne her husband a child, but this did not prevent them from drifting apart, until finally he left her. Harry Dobkin never went back to his wife, and she was forced to sue for maintenance. He was always in arrears with the payments. But in spite of all this there is little doubt that on that April day Rachel Dobkin was still very much in love with him.

With a simple faith Rachel still believed she and Harry could find happiness, and she was cheerful as she set out to meet him. Her family, with whom she lived in North-East London, knew in their hearts that reunion was impossible. But they did not disillusion Rachel, for she had always had a struggle to live and recently had been very ill.

Rachel never returned from that outing. Her sister waited up all night for her. There had been no sirens warning of an air raid, so where could she have been all night? Next morning, she reported her sister's disappearance to the police. They promised, in the usual way, to let her know if they received any news.

The next step came in the afternoon when Rachel Dobkin's handbag and ration book were found in Guildford Post Office, Surrey. But what had she been doing in Guildford? She knew nobody there. Now a little suspicious, the police asked Harry Dobkin to call in and see them. He was extremely calm and did not seem at all worried about the disappearance of his wife. He did not deny he had been with her that evening, but he stuck to a definite story: "We chatted together about this and that quite nicely for a bit. Then she started nagging at me. That started a quarrel, and she went off in a huff. By then it was dark, and off I went to Kennington Lane." The law had very little to work upon and certainly nothing

concrete against Harry Dobkin. They only knew Rachel had disappeared.

Rachel's sister was still convinced that something had happened, and took the handbag found in Guildford to a medium. The spiritualist told a strange story. She said its owner had come to a terrible end, that Rachel Dobkin had been struck down and strangled. The police were told about this, but, of course, it was not evidence, and matters stayed as they were for some months. Then, in July, 1942, a demolition squad set to work on a bombed site in Kennington Lane. Part of it was a half-destroyed chapel. A workman cleared away a layer of bricks and came upon a stone slab. He prised it up . . . and underneath was a skeleton. He thought he had discovered a legitimate grave, but his foreman noticed there were still tiny pieces of flesh on some bones and the police were called in.

It was not a new thing for demolition squads to find skeletons; many people were killed and buried beneath bomb rubble, to be found months later. But this one seemed to have been killed by other means than by a German bomb. Forensic science got to work, and in the laboratories a hunt for a killer began.

The remains had been mutilated to prevent identification. The facial skin had been removed, part of the jaw had been taken away, and the hands and feet were missing. The killer had even made a half-hearted attempt to burn the body. He must have thought he had done a perfect job, that the body would never be identified, and therefore would never be identified with him. But he was wrong.

At Guy's Hospital in London a group of scientists led by the famous Dr. Keith Simpson studied the bones. They were able to supply the police with many clues. The bones, they decided, belonged to a woman between 40 and 50. Amazingly, they were able to tell that she had suffered from rheumatism, and that she had once had a tumour removed.

By measuring the bones of the skeleton's upper arm, the scientists were able to give the woman's height as 154.5 cm. The time of death was at least a year previously. A minute bone, deep down in the throat, enabled Dr. Simpson to say that death had not been accidental — the woman had been strangled. This tiny bone is part of the voice box. It is heavily protected by flesh and muscle and cannot be broken accidentally — but it always fractures when hands grip the throat and exert enough pressure to cause strangulation.

While forensic science made even more discoveries, detectives went closely into the background of the little chapel in which the body had been found. Strangely, a special constable and a fireman remembered a fire there on the night of April 15th, 1941 — a night on which there had been no air raid. When it was found that a man named Harry Dobkin attended a nearby post as fire-watcher, police memories clicked. He was questioned again about the disappearance of his wife, but he stayed firmly by the story he had already told. He must have felt uneasy but at the same time confident. Until the police could prove without the slightest doubt that the chapel body was indeed Rachel's, he was fairly safe.

The police turned once more to forensic science. The resulting work has gone down in crime records through out the world. For sheer brilliance it had never been matched.

A check was made at all London hospitals for the records of women who had undergone tumour operations. At Mildmay Hospital, detectives found the operation record of . . . Rachel Dobkin. Next, Rachel's sister found a holiday snap taken just before the war and handed it over to scientists. They enlarged it to life-size and compared it with a photograph of the chapel victim's skull. It fitted exactly. They called on a dentist, who readily turned up the record card belonging to Mrs. Rachel Dobkin. Luckily he had scribbled a note on it which read: "Root gradually working its way to the surface."

An X-ray photograph of the skull was taken and this showed the root just as the dentist had noted. Moreover the part of the jaw that had not been cut away showed fillings and extractions just as they were on the dental record card.

The skeleton in the chapel was indeed little Rachel Dobkin. Thanks to forensic science, the police now had enough evidence to hang six men, and Dobkin was put on trial. He was found guilty and hanged in Wandsworth Prison.

TO BE CONTINUED

WINGS ON OUR SKIES

Top : The HF-24 Marut in flight

ON a hot summerday in 1961 the concrete runway near Bangalore stretched like a sheet bleached white by the midday Sun. A sleek, silvery white aircraft (Nehru, enchanted by its elegant design, had called it "the gazelle of the sky") stood on the runway providing the backdrop for about a dozen men, clad in white working overalls, posing for photograph. The aircraft was HF-24, the first fully Indian-designed jet fighter, and these were the proud men who had designed and brought it into being. Soon, amidst the familiar shrill whine of the jets, the aircraft took to the skies, and with it a new era was ushered in the history of the Indian aircraft industry.

When Seth Walchand Hirachand set up the Hindustan Aircraft Ltd in December 1940 to assemble in India Vultee Vengeance and other aircraft (in collaboration with the Intercontinental Corporation of the United States), he could have hardly foreseen that in less than three decades it would evolve into a huge complex with 22,000 personnel on its payroll.

In its early days, the Hindustan Aircraft had to remain content with its aircraft assembly role only. But when an Engineering and Designing section was set up, it came out with the first Indian-designed powered aircraft, the HT-2 basic aerobatic trainer.

In early 1960, India also started producing under licence the HS-748 twin turboprop transport aircraft at the Aircraft Maintenance Depot of the Indian Air Force at Kanpur. This unit came to be called later Aircraft Manufacturing Depot. However, today, coming into limelight is the MiG-21 complex. It was started after the Soviet Union had agreed to let India produce under licence these supersonic fighters (following the Chinese aggression in 1962). Soon the Aircraft Manufacturing Depot at Kanpur and the MiG complex were combined to form the Aeronautics India Ltd. And in 1964, when the Hindustan Aircraft Ltd of Bangalore joined in, the nationalised Indian aircraft industry came to be known as the Hindustan Aeronautics Ltd (HAL, for short).

Now the Kanpur division of HAL produces the HS-748, and its MiG complex, scattered over three centres, has the airframe and final

assembly unit at Nasik, engines unit at Koraput and the electronic equipment unit at Hyderabad.

The most important unit of this organisation, however, is its Bangalore division. It produces the Gnat and HF-24 Marut fighters, the HJT-16 Kiran jet trainer, the light aircraft Pushpak and Krishak, and the Alouette III helicopter. The shops of this division are equipped with some of the most sophisticated equipment available, including automatic milling machines, rubber presses and hydroscopy spar mills. It has also its own flight test laboratory, structural test facilities, etc. A major disadvantage of this organisation is that, in the absence of a well-developed ancillary industry, it has to produce all components, including plastic cockpit canopies, by itself.

Aero-engine factory

About a decade back, an aero-engine factory had been set up at Bangalore to produce under licence the Bristol Siddeley Orpheus turbojets for the Gnat and later for the HF-24 Mk 1A fighters. Now known as the Engine Division, this plant is also producing the Rolls Royce Dart turbo-prop engines for the Kanpur-assembled Hawker Siddeley HS-748 aircraft and will shortly undertake production of Turbomeca Artouste IIIB turboshaft engines for the Allouette III helicopters, followed by HJE-2500 turbojet for the HJT-16 trainer.

Bangalore has also facilities for the overhaul and repair of a number of aircraft and engines in operation with the Indian Air Force.

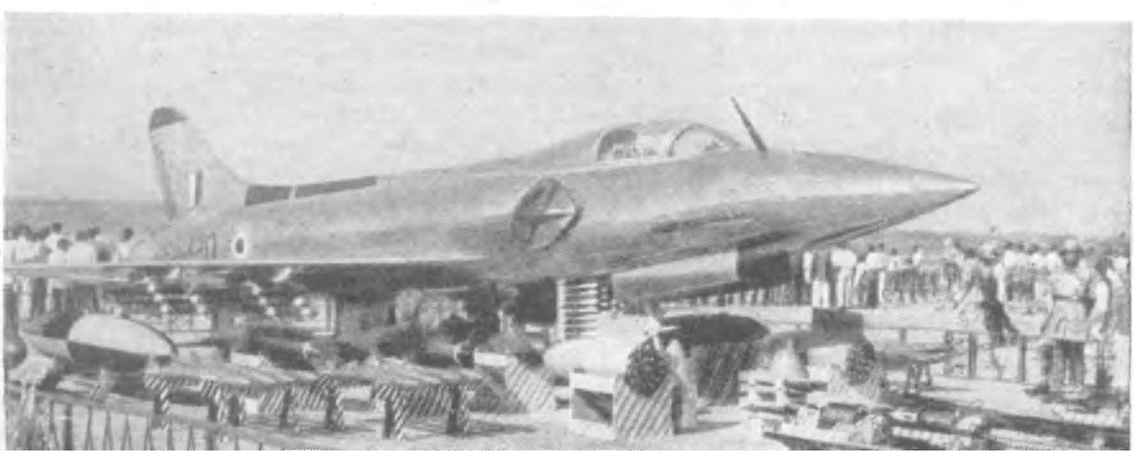
The design work on India's first indigenous fighter, the HF-24, began in 1956, with the well-known German aircraft designer Dr. Kurt Tank heading the team. It made its maiden flight on 24 June 1961. The Mk 1R version of this aircraft fitted with reheat is at present in an advanced stage of development. Work is also going on on a night fighter, a trainer version, and a Mach 2 interceptor.

HT-2 basic aerobatic trainer, the first aircraft designed and made in India

The HF-24 is powered by two Orpheus-703 turbojets mounted in the fuselage. The reheat system of the Mk 1R version enables it to fly at Mach 1.4 for short durations.

Though the HF-24 Mk 1A is only a transonic aircraft (i.e. in the range of about Mach 0.9 to 1.2), it is the fastest fighter in the Indian Air Force with the exception of the MiG-21. It is designed as a ground attack aircraft and, in that role, does not need a much higher performance. A major advantage of the HF-24 is that it can carry a formidable range of underwing stores including 1,000-lb bombs and air-

HF-24 on display at an air exhibition with complete range of weapons it can carry in various combinations



to-ground rockets. Other armament includes four 30-mm cannons in the nose and a retractable pack of forty-eight unguided rockets below the fuselage. The two-engined layout is another favourable factor and, as the recent airwar in Vietnam has proved, a twin-engined aircraft stands a better chance of survival in the event of an engine failure or a non-fatal hit from an enemy gun. While it has a fairly good range, this can be further increased with external fuel tanks.

The other fighter aircraft India possesses is the Gnat. The Gnats shot into prominence during the war between India and Pakistan in 1965. The impressive list of " kills " they made of the US-built Pakistani Sabre jets gave this midget fighter a tremendous boost.

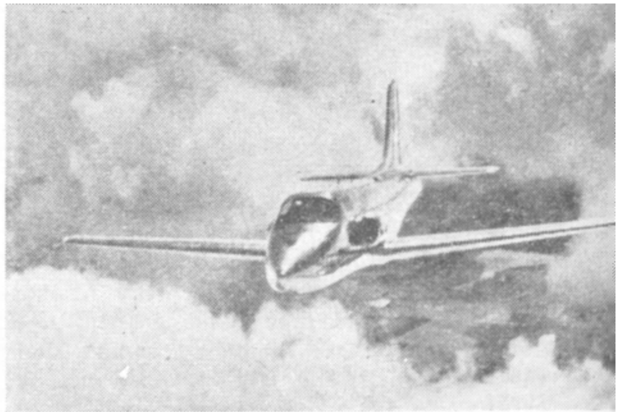
The Gnat was produced by the British company Folland Aircraft Ltd which was later taken over by Hawker Siddeley Aviation. It was one of the earliest successful attempts at producing a low-cost and easy to manufacture jet fighter. The Gnat is being produced in India under licence at Bangalore.

By far the smallest transonic jet fighter in the world, the Gnat can easily outmanoeuvre any other jet fighter in aerial combat. It has a very good rate of climb and its armament of two 30-mm guns, located adjacent to the air intakes, offers sufficient fire power for conventional aerial combat. The Gnat is also less vulnerable to enemy fire as it does not have any fuel in the wings. All these qualities were amply demonstrated during the Indo-Pakistani war of 1965. The Gnat can also carry two 1,000-lb bombs or an equivalent weight in rockets, but it is at its best as an interceptor.

The design of the Gnat has simplicity as the keynote and its manufacturer had claimed at the outset that it could be produced in one-third the time and at one-fifth the cost of a large, highly sophisticated fighter.

MiG-21

By far the most important aircraft currently in production in India is undoubtedly the Mikoyan-Gurevich MiG-21. This is one of the most widely used jet fighters in the world today. Different versions of it are in service with the air-



HJT-16 Kiran jet trainer in flight

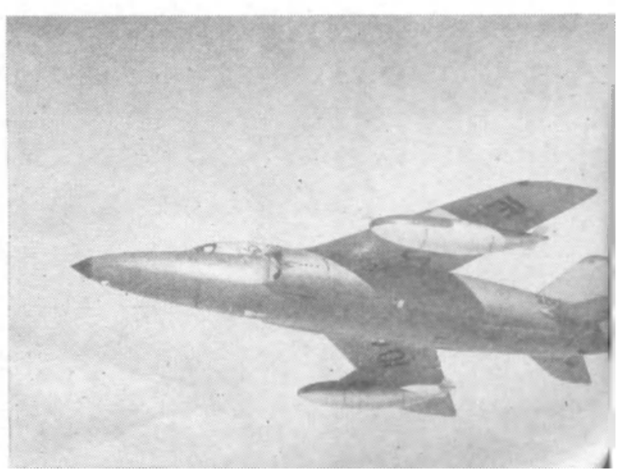
forces of the Soviet Union as well as a number of East European countries, China, North Korea, some of the Middle East countries, Finland, Cuba and North Vietnam. It has been described as a pilot's aircraft and, from this viewpoint, is a fine aircraft for interceptor role.

Capable of flying at up to Mach 2 (twice the speed of sound), the MiG-21 is comparable in performance to the French Dassault Mirage. The Israelis, who by now possess at least one MiG-21, have after fully evaluating it claimed that in some respects it is actually better than their Mirage. Main armament of the MiG-21 consists of two 30-mm guns and two air-to-air missiles similar to the American Sidewinders.

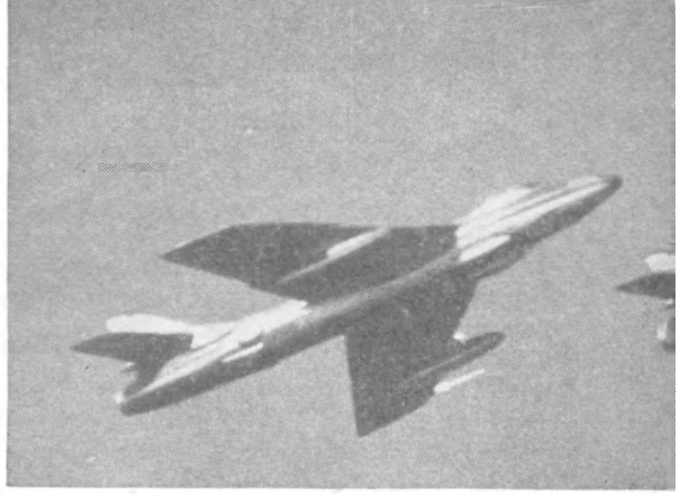
India also possesses a number of MiG-21 fighters and trainers directly purchased from the Soviet Union and these are already in service with the Indian Air Force.

Among the other transonic and subsonic fighters at present in service with the Indian Air Force are the British Hawker Siddeley Hunter and the French Dassault Mystere IVA

The Gnat fighter (photo shows an early version)



and Ouragan. The Hunter is the most successful jet fighter produced by Britain and almost two thousand of them have been built. Today it is no longer in production, but the aircraft is still in demand and Hawker Siddeley have been buying up old European Hunters, reconditioning them and then reselling them to a number of countries including India. Along with the Gnat, the Hunter still forms the backbone of the IAF fighter squadrons, though this position is being rapidly taken over by the MiG-21 and to a lesser extent by the HF-24 Mk 1A. The Mystere IVA has a comparatively lower performance, while the straight-winged, subsonic Ouragan (named Toofani by the IAF) is used mainly in the ground attack role.



Two transonic Hunter jet fighters flying in formation

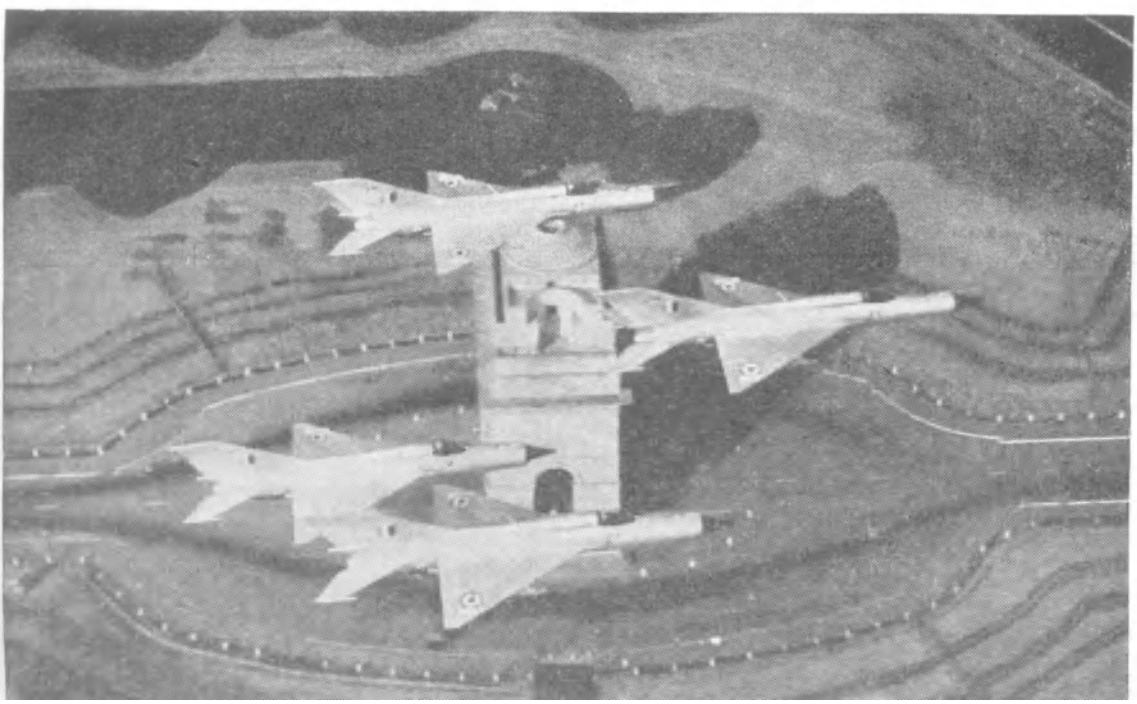
Jet trainer

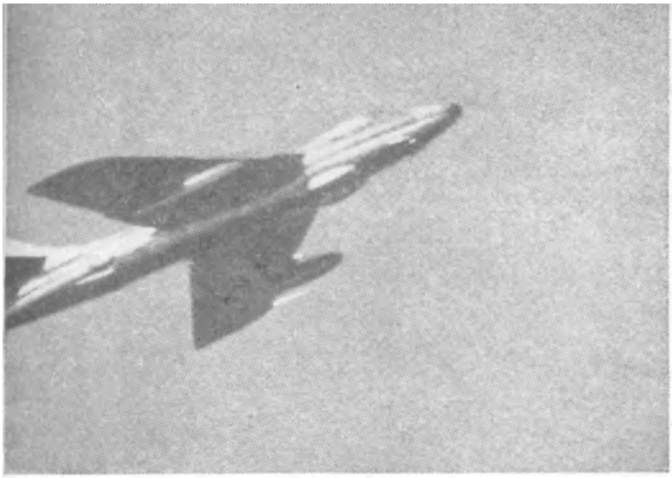
The HJT-16 Kiran basic/intermediate jet trainer is the second indigenously designed jet aircraft to be made by the Bangalore division. Designed by Dr. V. M. Ghatage, work on this aircraft started in 1961. This trainer is intended to operate under tropical conditions, and is of an extremely simple, straightforward design. It is powered by a Bristol Siddeley Viper 11 turbojet engine. At a later stage, indigenously designed and produced HJE-2500 turbojet engines may be used.

Among the other aircraft being produced at Bangalore are the four-seater Krishak STOL (short take-off and landing) multi-purpose aircraft and the Pushpak two-seater ultralight trainer.

Designed to meet India's requirement for a rugged, ultralight aircraft, the Pushpak is one of the lowest priced two-seater aircraft in the world. It is fitted with dual controls which make

A formation of MiG-21s passing over the India Gate in Delhi





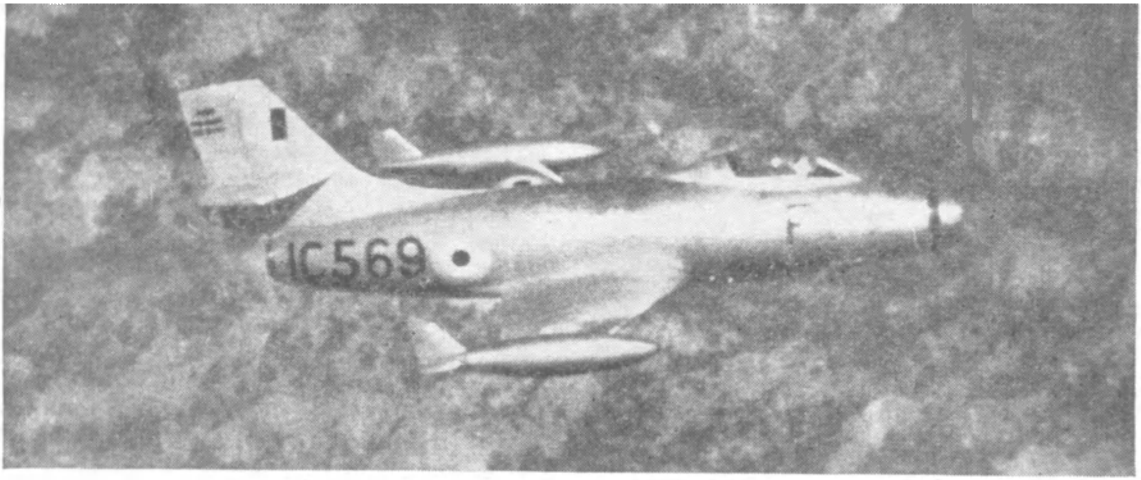
it suitable as a trainer. However, the Pushpak is not a lively aircraft and beyond undertaking level flights at about 135 kmph, there is little else it can do. Its inherent safety makes it highly suitable for flying club use. The Pushpak is at present powered by a Continental C-90-8F reciprocating engine of 90 horse power, but at a later stage it will be fitted with an Indian-designed engine.

Similar in appearance to the Pushpak, but a larger, four-seater aircraft is the Krishak. Its STOL capabilities permit it to operate from small, unprepared airstrips. The Krishak is powered by a single Continental O-470J reciprocating engine of 225 horse power which gives it a maximum speed of 240 kmph. A small number of Krishaks are at present in service with the Indian Air Force, mainly for ambulance and liaison duties.

The Bangalore division is also reported to be working on a small agricultural aircraft and a supersonic twin-engine, long-range, ground attack aircraft.

The twin turbo-prop HS-748, now being produced under licence by the Kanpur division, was designed by the British firm Avro which later merged with the Hawker Siddeley group. It is Britain's best selling turbine engined aircraft and total orders for it exceed 170 units. At present, about forty-four of these aircraft are being produced in India to meet the requirements of the Indian Air Force and Indian Air-

Right: (top) The French-designed Alouette helicopter; (centre) HS-748 turbo-prop passenger aircraft built at the Kanpur division of the HAL; (below) the single-engined Krishak



The French-built Ouragan (called Toofani) jet fighter of the IAF

lines. While the IAF has ordered it for the transport of personnel, for dropping paratroopers and as a trainer, Indian Airlines has employed it as a passenger transport to link some of the smaller cities on its routes.

Helicopters

While the Indian Air Force has operated over the years several helicopters of different makes including the Bell 47, Alouette II, Mil Mi-4, Sikorsky S-55 and S-62, it was only recently that India joined the ranks of helicopter-producing countries. Some years back, India obtained a licence from Sud-Aviation of France to produce the Alouette III helicopter at Bangalore. The Alouette is at present Europe's best selling helicopter and well over 1,500 Alouette IIs and IIIs have been sold to date. Sud-Aviation are Europe's largest helicopter manufacturers. They also produce the Caravelle jetliner in service with Indian Airlines and the Centaure sounding rockets produced under licence in India.

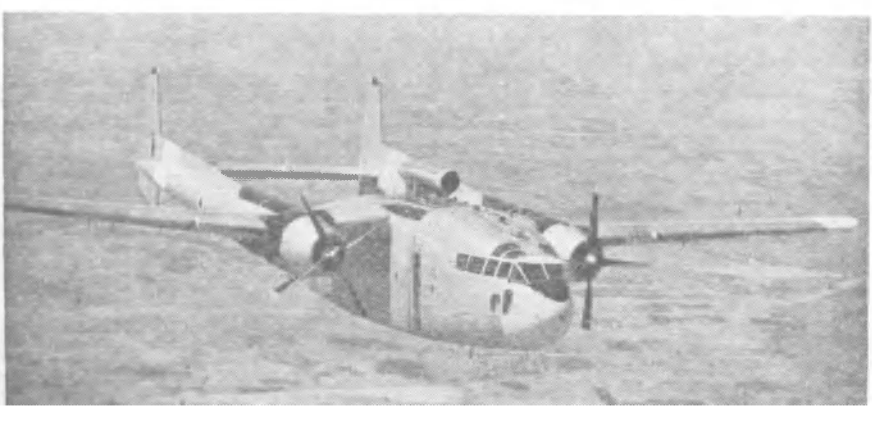
The Alouette III is a six-passenger helicopter powered by a Turbomeca Artouste IIIB engine. While the Indian Air Force is using the Alouette III mainly for transportation of troops and supplies at high altitudes, the Indian Navy uses it for air-sea rescue work. The Alouette III can also be equipped with a wide range of lethal weapons.

Engines

Hindustan Aeronautics Engine Division at Bangalore is at present producing both the Orpheus turbojet and the Dart turbo-prop engines under licence.

The Bristol Siddeley Orpheus Mk 701 is used to power the Gnat fighter and also as an auxiliary engine for the Fairchild Packet — piston-engined transport aircraft—to improve its high-altitude performance. The Rolls Royce Dart has proved to be the most popular turbo-prop engine ever developed and several thousand of them have been produced to date. It is being built under licence in India for the

Below: (left) A Fairchild Packet aircraft flying with the aid of a jet pack mounted on top. Both the propellers have been switched off (feathered). (Right): A long line of canberras (bombers not produced in India) of the IAF, parked at a base



HS-748 assembled at Kanpur.

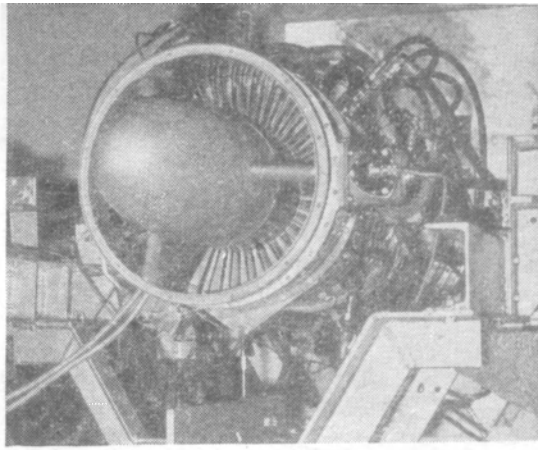
Apart from these engines, the Engine Division has been working on the design of a light turbo-jet, designated the HJE-2500, to power the Kiran jet trainer. This engine is still in an early stage of development and will require some more time to go into production. Work is also in progress on a small, four-cylinder piston engine for the Pushpak.

Research

An aircraft industry always requires the backing of extensive research facilities and of educational institutions. At present, the most important research institution is the National Aeronautical Laboratory (NAL) at Bangalore. The NAL has set up a large Wind Tunnel Centre at Belur which has 1 ft × 1 ft and 4 ft × 4 ft (1 foot equals about 30 cm) trisonic wind tunnels among its equipment. Other equipment available range from slow-speed tunnels to small transonic and supersonic wind tunnels. At Kodihalli, the NAL has its Structures and Materials Division. As the name suggests, it is for testing aircraft materials and structures.

India's major centre of research in the engine field is the Gas Turbine Research Establishment at Bangalore which developed the after-burner for the Orpheus turbojet to obtain a higher thrust.

An important aerodynamics research centre is the Indian Institute of Science, Bangalore. It has its own large, slow-speed wind tunnels and also a number of small, supersonic wind tunnels. Much useful work in aerodynamics and structures is being done here and the Institute is also the country's main source of aeronautical engineers and research workers. Other institutions like the various Indian Institutes of Technology, notably the one at Kanpur, are

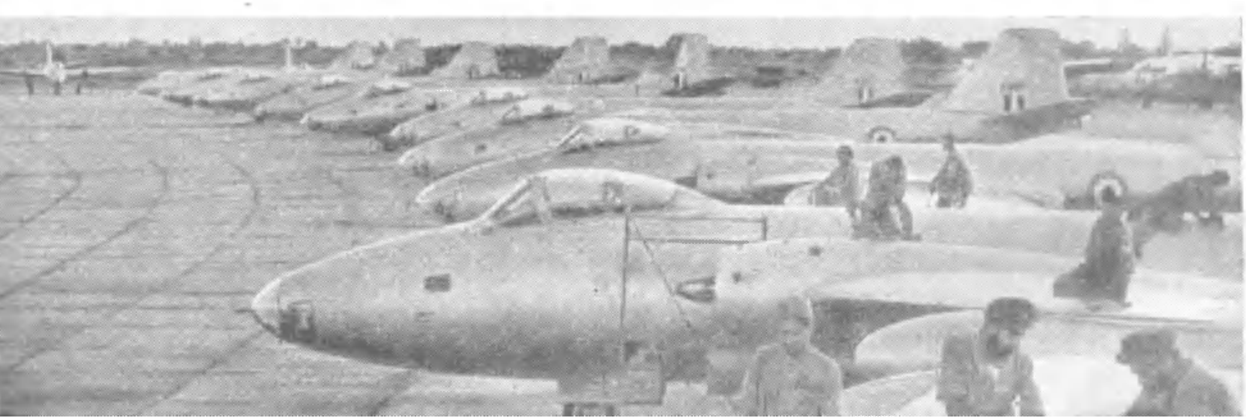


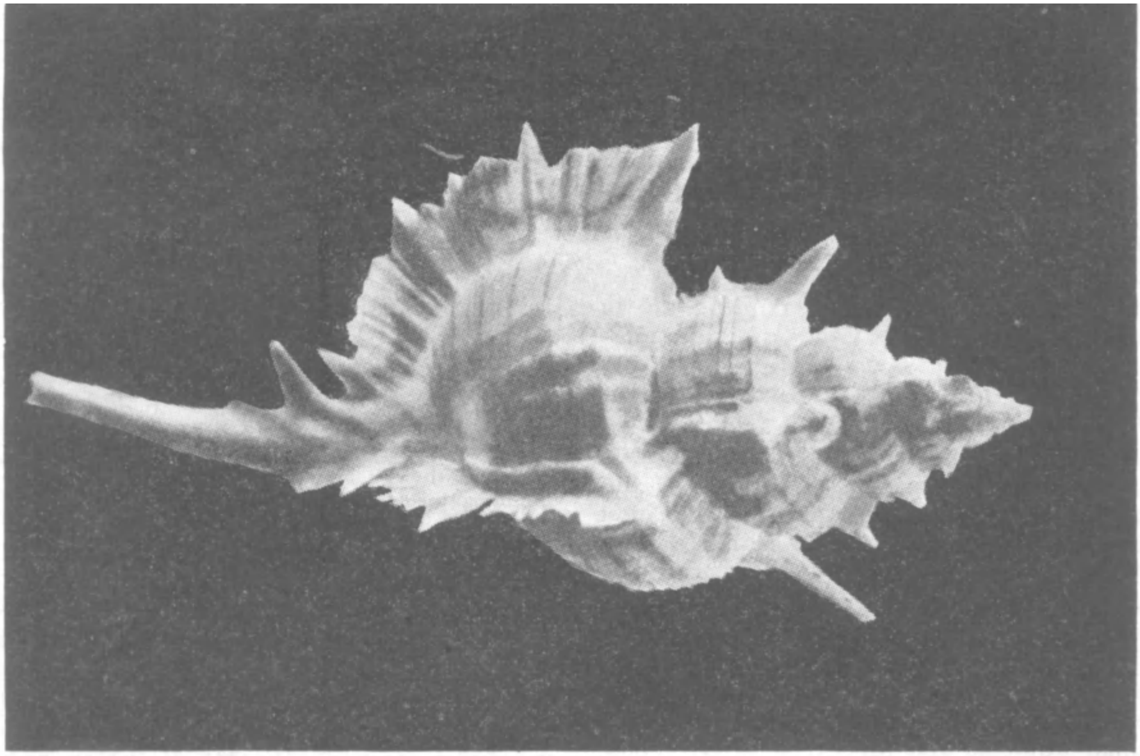
HJE-2500, the country's first jet engine, designed by the Bangalore division

helping to meet the requirement of skilled manpower. They are also undertaking some useful aeronautical research.

While India has developed the capability to design high-performance aircraft like the HF-24 and HJT-16 to meet its requirements, it still has a long way to go in undertaking volume production. The HF-24, which first flew in 1961, is only now entering squadron service. Only a limited number of HF-24s have been delivered to the Indian Air Force so far. And though test runs on the HJE-2500 engine have already been made, it is unlikely to be available for some years yet and, at this rate, only a small number of Kirans may be powered by the Indian designed engine.

Again, the Mk-2 supersonic version of the HF-24 is still without an engine. The HAL is now thinking of designing an engine for it at its Engine Division. But at its present rate of functioning, such an engine is bound to take a long time and, by then, the airframe itself may have become obsolete. Unless a readily available foreign engine is found soon, the HF-24 Mk 2 aircraft faces the danger of being altogether scrapped.





THE SHELL GAME

JOHN & MOLLY DAUGHERTY

A SCALLOP is the pilgrim's symbol. In the eighth century, pilgrims going to the shrine of Saint James at what is now Santiago de Compostela, Spain, took shells back home to prove they had made the trip. (The scallop was the symbol of Saint James, the fisherman.) Natives gathered the shells on Mediterranean shores and took them inland.

You can find shells anywhere, however — at sea, on land and in fresh water. A rare shell, the Conus gloria maris, of which few specimens are found, has been valued at more than Rs. 9,000.

What do you know about shells?

1. **Natural pearls form in the pearl oyster**
   - **a. As eggs develop in hens**
   - **b. In its effort to avoid discomfort**
   - **c. With regularity once a year**
2. **One mollusk is a symbol of good luck and long life to the Japanese. Their gift packages often include colourfully wrapped thin slices of the dried meat of this animal. The good-luck mollusk is the**
   - **a. Abalone**
   - **b. Periwinkle**
   - **c. Conch**
3. **The shells for making cameos are found among**
   - **a. Wentletraps**
   - **b. Cowries**
   - **c. Helmets**
4. **With a few exceptions, mollusk animals have hard shells which grow with them. The growth of the shells is**
   - **a. A continuous process**
   - **b. A periodic process**
   - **c. An unknown phenomenon**
5. **The number of shell species of all classes of known mollusks is about**
   - **a. 100,000**
   - **b. 250,000**
   - **c. 50,000**
6. **Single-shelled univalves make up the largest class — the gastropods. Pelecypods, the second largest class (bivalves), include oysters, mussels and clams. The mollusk among these that grows biggest in size is the**
   - **a. Oyster**
   - **b. Mussel**
   - **c. Clam**

7. **Experts judge the value of pearls on many points, but usually the first criterion in determining the value comes from**
   a. **Texture and colour**
   b. **Freedom from blemish**
   c. **Shape and shining quality**
8. **To avoid a venomous mollusk, the stab of which could be fatal, beware of some varieties of**
   a. **Cockles**
   b. **Cones**
   c. **Cowries**
9. **Snails are mollusks. One of these snails was the source of dye in the time of the Phoenicians and led to a flourishing industry. This snail was the**
   a. **Natica snail**
   b. **Moon snail**
   c. **Murex snail**
10. **The best time for collecting live shells is at**
   a. **High tide**
   b. **Low tide**
   c. **Midway between high and low tide**

Answers:

1 — b. In its effort to avoid discomfort. When sand or other material lodges in the soft body of the oyster or between its shell and mantle, the animal covers the object with a liquid which hardens quickly into a smooth coat. As the process of coating continues again and again, the pearl grows in size. Narce, the liquid, is the same as that which forms the mother-of-pearl lining of the shell.

2 — a. Abalone (*Haliotidae*). The muscular foot is a food delicacy. Abalone is a staple oriental food, as well as a symbol of good luck and long life to the Japanese.

3 — c. Helmets (*Cassididae*). Several varieties of helmet shells may be used. Many tons of red helmet shells (*Cypraecassis rufa*) are shipped to Italy from Africa to make fine cameos. Black and yellow helmets are two of the choice-shells (for cameos) found in American waters.

4 — b. A periodic process. At times, growth slows down or even stops. State of activity, environmental conditions and food supply affect growth. Liquid secretions of calcium carbonate flow from glands along the edge of the mantle (the fleshy lining of the shell). When mixed with colloidal albumin, also supplied from glands of the mantle, the liquid crystallises to form additions to the shell. Other glands over the area of the mantle supply secretions to build the shell in thickness, too.

5 — a. 100,000. Most mollusks belong to the gastropods and pelecypods. There are three minor classes: Scaphopods — tusk and tooth shells; cephalopods — chambered nautiluses; and amphineurans — chitons or coat-of-mail shells.

6 — c. Clam. The giant clam (*Tridacna gigas*) of the southwestern Pacific and Indian Ocean waters may reach 3 metres in length and 200 kg in weight. It is a vegetarian with a possible life span of 100 years. The cone, in contrast, is carnivorous. It eats fish and even eats members of its own family.

7 — c. Shape and shining quality. The lustre is called its orient. The quality of the shell lining and of the pearl depends on the chemical content of the water, the type of food supply (microscopic organisms) and the temperature of the water and its saltiness.

8 — b. Cones. Some cones (*Conidae*) are harmless but others are deadly.

The cone has a long retractable fleshy tube for a proboscis. Poisonous ones have five or more harpoon-shaped needles for stabbing enemies and injecting the venom.

9 — c. Murex snail (*Murex brandaris*). The Phoenicians made a rich purple dye known as " Tyrian purple " by crushing vast numbers of Murex snails. Demand for the dye was so great that the Phoenicians colonised many parts of the Mediterranean in search of new beds of snails. When the Romans took over, only royalty could wear this purple.

The glands on the wall of the mantle of the snail first exude a milky white fluid, which on exposure to sunlight goes through a series of colour changes ending in red-purple.

10 — b. Low tide. Especially the extra low tides or minus tides. Some kinds of shells can be found at no other time. Often all you see of some specimens are their siphons sticking up out of the mud of sand. If you dig one up and place it on the surface, you will soon see its foot emerge to dig under again.

Another time to look for live shells is right after a severe storm, when many shells may be washed ashore.

Score Yourself

9 — 10 right — You'd be a good malacologist

4 — 8 right — The shell world isn't quite your oyster

0 — 3 right — You were a real clam

For Young Readers

MAGIC OF THE AUTO EXCHANGE

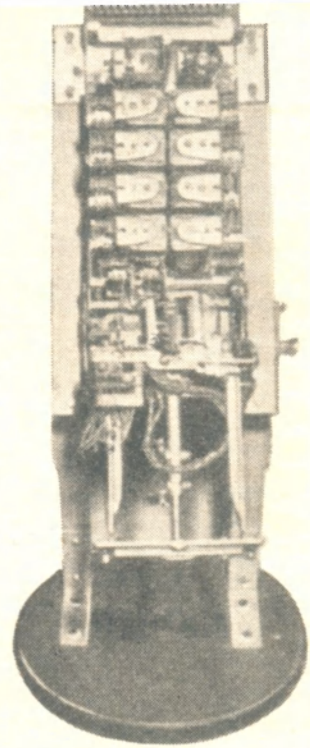
J. M. PARANJPAY

YOU pick up the telephone receiver on your table and dial six numbers. The next moment, your friend answers. The whole town is at your dialling finger-tips. Sounds like magic, doesn't it ?

But it is a magic only if you don't know the science of it. The way in which the auto telephone exchange can distinguish the number dialled by you from so many others is simple.

Imagine a visitor in search of his friend's flat, out of several flats in a 10-storeyed building. Suppose there are hundred flats in all, 10 flats on each floor. The visitor searching for flat No. 73 climbs 7 staircases and then walks horizontally to the 3rd flat on that floor. A two-motion selector, which is a basic element in an auto telephone exchange, behaves identically. It takes seven vertical steps and three horizontal steps if number 73 is dialled.

But this method will succeed only if there are 100 subscribers connected to the telephone exchange. The principle can be used for more subscribers by adding one more selection stage. The visitor has now to search for his friend's flat No. 73 from a building No. 37 (say) from several buildings located on various



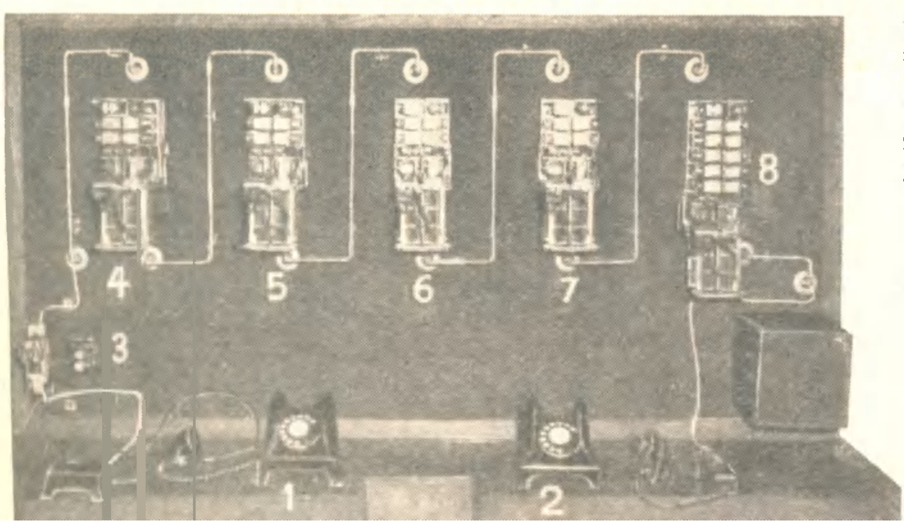
The two-motion selector

parallel roads. He finds out the desired flat in two stages:

1. Finding the 7th building on the 3rd street
2. Finding the 3rd flat on the 7th floor

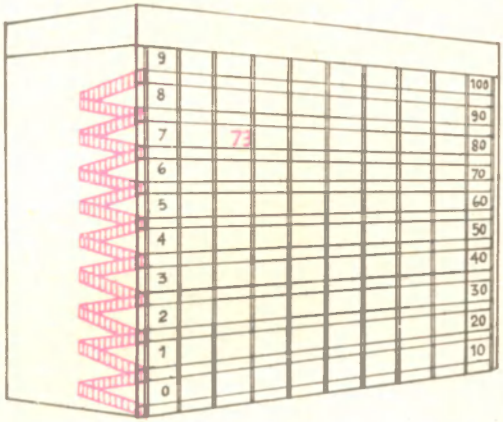
In an auto exchange this is equivalent to selecting a called number 3773. This is why the system is known as a step-by-step system.

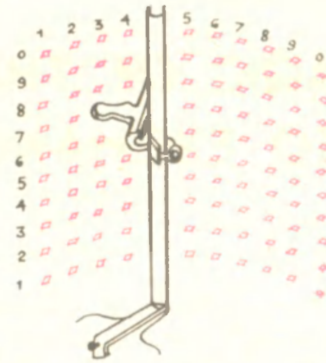
For each user of a strowger auto telephone exchange, there is a rotary switch called the uniselector, but the other switching equipment is common to all its users which they share as per individual needs and according to the availability at the time.



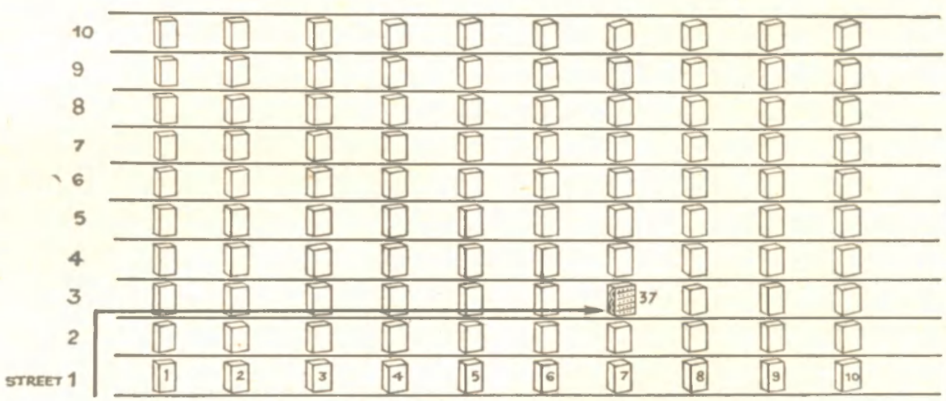
Left : Switching Train in an auto telephone exchange

1. **Caller**
2. **Called party**
3. **Rotary switch of caller**
4. **1st selector stage**
5. **2nd " "**
6. **3rd " "**
7. **4th " "**
8. **Final " "**





Above : Looking for the 73rd flat — climb 7 floors and find the 3rd room. The two-motion selector (right) of an auto exchange does the same. Below : Locating the 37th house in an area of 100 houses. Each block represents a house ; go to the 3rd street (assuming all the roads are parallel) and then to the 7th house. The diagrams above and below jointly gives the location of number 3773 — finding the 73rd flat in the 37th house in a locality of 100 houses, each with 100 flats



In a 10,000-line exchange, for example, there will be 10,000 uniselectors and a few thousand two-motion selectors forming sequential stages. In big cities where each telephone number has 6 digits, there will be 5 selector stages. When you lift your receiver, the uniselector hunts for a free first selector which also gives him the dial tone. (This tone is an alternating current of frequency $33\frac{1}{3}$ cycles per second passing through the receiver.)

When you dial the first digit (say 4), the first selector takes 4 vertical steps and then searches for a second selector by rotating horizontally. The procedure is similar in each one of the 2nd, 3rd and 4th stages. The 5th selector (also called the final selector) responds to the last 2 digits since there is no more selection stage to be searched for. The final selector is connected to the called line and gives a busy tone if the called subscriber is busy. This tone can come after dialling a part of the total digits, if a particular selector finds all selectors in the next stage busy.

Ringing, dial tone, busy tone and ring-back tone, are electric currents of different pitches and are produced by a machine similar to a dynamo. You might have noticed that the ring which is given on the called line is quite different from, and independent of, the ring-back received by the calling line. Although the

(continued next page)

calling party gets a feeling that he is hearing the ring tinkling on the called telephone.

Telephone calls are registered automatically when the called party lifts the receiver. Each user is allotted a meter which is just a coil of wire, a current through which operates a mechanism similar to the milometer in your car.

Basically, every telephone connection requires a pair of wires. From the telephone on your table, this pair is connected to an underground cable which also contains a number of other pairs serving your neighbours.

These cables are led to the exchange and terminate on a frame, the other side of which is connected to the exchange equipment. The equipment cannot be connected to the subscriber's pairs of wires directly, because, due to accidental contact with high voltage electrical wires, the telephone line may expose the exchange equipment to high tension and high current damage. On the distribution frame are, therefore, devices to protect the equipment from high currents and high voltages.

The capital cost of an auto exchange equipment is high, hence only a city having a demand for more than 1,000 telephone lines gets an auto telephone exchange.

Answer to last month's puzzle

When the steamers meet for the first time, the combined distance covered by them equals the width of the river. When they reach the opposite banks, the combined distance travelled is twice the river's width, and when they meet the second time, together they have covered three times the river's width.

Since the steamers have been moving at a constant speed for the same period of time, each boat has gone three times as far as when they first met and had together travelled one river width. The first steamer had travelled 720 metres before the first meeting and during the second meeting, she must have travelled 3×720 or 2,160 metres. This we know is 400 metres more than the river's width. Therefore, the river is 1,760 metres wide. The time the steamers remained at their landings does not enter the problem.

There is another way to solve the problem: Let X be the river's width; on the first trip, the ratio of distance travelled by the steamers is $X - 720$: 720. On the second trip it is $2X - 400$: $X + 400$. These ratios are equal; hence it is easy to solve for X.

For Further Reading

BEGINNING OF CIVILISATION IN SOUTH INDIA
(pp. 24-36)

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3. "Megaliths" by Gordon Childe (*Ancient India*, No. 4, 1947-48)
4. *Indo-Asian Culture, Vol. II* by Christeph von Furer-Haimendorf (1954), and Presidential Address, Anthropology and Archaeology Section, Indian Science Congress, 1950
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6. "From the Megalithic to Harappa" by B. B. Lal (*Ancient India*, No. 16, 1960)
7. *Stone Age of Tekkalkota* by M. S. Nagaraja Rao and K. C. Malhotra (Poona) 1965
8. "Stone Age Hill Dwellers of South India" by H. D. Sankalia (*Indica, Vol. I*, 1964)
9. "Human Skeletal Remains from Brahmagiri" by S. S. Sarkar (*Bulletin of the Department of Anthropology*, No. IX, 1960)
10. "Problems of Post-Harappan Archaeology in the Lower Indus Valley and Baluchistan", by Walter A. Fairservis (*Journal*, M. S. University of Baroda, *Vol. XV*, 1966)

PUZZLE OF THE MONTH

THIS is a problem of logic.

1. In 1918, the day World War I ended, three married couples were having a celebration dinner.
2. Each husband is the brother of one of the wives, and each wife is the sister of one of the husbands, i.e. there are three brother-sister pairs.
3. Helen is exactly 26 weeks older than her husband, who was born in August.
4. Mr. White's sister is married to Helen's brother's brother-in-law. She (Mr. White's sister) married him on her birthday, which is in January.
5. Marguerite White is not as tall as William Black.
6. Arthur's sister is prettier than Beatrice.
7. John is 50 years old.

What is Mrs. Brown's first name ?

Answer next month

YOU TOO CAN DO IT

POCKET RADIO

WANT to have a portable transistor radio of your own ? Here is a way. It won't cost you more than about Rs. 30.

The circuit can be broken down into five sections as shown by the dotted lines in the figure.

Antenna or aerial: Any metallic wire or measuring steel tape about a metre long which can stand straight can be used as antenna. Steel tape or telescopic antenna is preferred because they can be folded when not in use. The antenna intercepts radio waves which induce tiny currents in the wire, starting an electron flow in the wire.

Tuner: The tuner consists of a ferrite rod with medium wave antenna coil and the variable condenser connected in parallel with it. If the coil has two windings then use the coil with larger number of turns. The antenna is connected to one end of the combination. The tuner enables you to select waves from any particular station. The receiver coil and the variable capacitor allow only a particular wave frequency to circulate in the tuner. Other lower and higher frequencies are short circuited to ground.

Detector: It is a diode valve connected to the tuner circuit. The diode has two leads. It is a one-way path for electrons which can flow in one direction only. The diode separates the programme modulated on the radio wave.

Two-stage amplifier: An electrolytic condenser having polarity is connected between the diode and the first transistor. The polarity of the leads are denoted on the adjacent part of the body which should be noted while connecting it in the circuit.

The resistances have two leads. As they have no particular polarity, they can be connected in any way. The values of the resistances are denoted in colour code rings:

1 Meg ohms	Brown	Black	Green
100 K ohms	Brown	Black	Yellow
47 K ohms	Yellow	Violet	Orange

There may be a fourth ring with silver or golden colour which denotes the tolerance of $\pm$ 10% and $\pm$ 5% respectively.

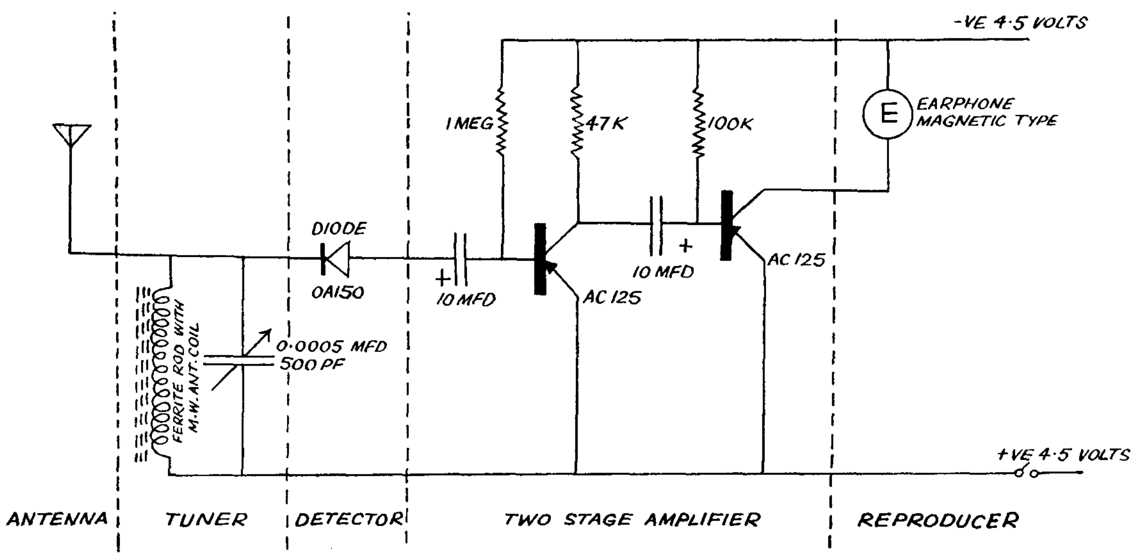
The programme signals at the detector are applied to the base-emitter circuit of the transistor. Here the weak programme signals are amplified. The process is repeated to provide sufficient amplification to drive the reproducer.

Reproducer: The magnetic earphones or headphones can be connected in any way since they have no particular polarity.

You will need:

Transistors: AC125 or 2SB75 or equivalent (two pieces); *Diode:* OA150 or OA70 or equivalent; Headphone or earphone — magnetic type; Ferrite rod with coil for medium wave; *Resistances:* 100K, 47K, 1 Meg ohms; *Condensers:* 0.0005 mfd or 500 of variable 10 mfd — 6 volt (two pieces); Telescopic antenna or stiff wire about 1 metre long; *Batteries:* i.e. three 1.5 volt cells in series (4.5 volt); and on/off switch, lug strips, wires, knob suitable enclosure.

Anil V. Borkar



Questions & Answers

What is the fourth dimension?

THE word "dimension" is from Latin and means "to measure completely". Let us try a few measurements, then.

Suppose you have a line and want to locate a fixed point, *X*. You make a mark anywhere on the line and label it "zero". You then make a measurement and find that *X* is just ten cm from the zero mark. If it is on one side, you agree to call the distance + 10; if on the other side, it is — 10. Your point is located, then, with a single number.

Since only one number is needed to locate a point on a line, the line or any piece of it, is "one-dimensional" ("one number to measure completely").

Suppose, though, you had a large sheet of paper and wanted to locate a fixed point *X* on it. You begin from your zero mark and find it is 5 cm away — but in which direction? You can break it down into two directions. It is 3 cm north and 4 cm east. If you call north plus and south minus, and if you call east plus and west minus, you can locate the point with two numbers: + 3, + 4.

Or you could say it was 5 cm from the zero mark at an angle of 36·87° from the east-west line. Here again are two numbers: 5, 36·87°. No matter how you do it, you must have two numbers to locate a fixed point on a plane. A plane or any piece of it is two-dimensional.

Suppose now that you have a space like the inside of a room. A fixed point, *X*, could be located as 5 cm north of a certain zero-mark, 2 cm east of it, and 15 cm above it. Or you can locate it by giving one distance and two angles. However you slice it, you will need three numbers to locate a fixed point in the inside of a room (or in the inside of the universe).

The room, or the universe, is therefore three-dimensional.

Suppose there were a space of such a nature that four numbers, or five, or eighteen, are absolutely required to locate a fixed point in it. That would be four-dimensional space, or five-dimensional space, or eighteen-dimensional space. Such spaces do not exist in the universe, but mathematicians can imagine such "hyperspaces" and work out what the properties of mathematical figures in such spaces would be. They even work out the properties of figures that would hold true for any dimensional space. This is "*n*-dimensional geometry".

But what if you are dealing with points that are not fixed, but that change position with time? If you wanted to locate a mosquito flying about a room, you would give the usual three numbers: north-south, east-west, and up-down. Then you would have to add a fourth number representing the time, because the mosquito would have been in that spatial position for only a particular instant, and that instant you must identify.

This is true for everything in the universe. You have space, which is three-dimensional and you must add time to produce a four-dimensional "space-time". However, time must be treated differently from the three "spatial dimensions". In certain key equations where the symbols for the three spatial dimensions have a positive sign, the symbol for time must have a negative one.

So we mustn't say that time is *the* fourth dimension. It is merely *a* fourth dimension, and different from the other three.

Isaac Asimov

"Hello, Chief? I think I've discovered the source of those mysterious fires."